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VOL. 2—No. 3 NOVEMBER 1930 (*Proceedings Vol. 27*)

JOURNAL
of the
AMERICAN CONCRETE INSTITUTE

News Letter

BINDING YOUR FIRST JOURNAL VOLUME

TO GIVE additional opportunity to members who wish to take advantage of a special arrangement with the Michigan Book Binding Co., to have the Proceedings and Abstracts Pages (Nov. 1929 to June 1930) bound uniform with previous annual volumes, the time is extended to Dec. 1. PACK your JOURNALS securely (some packages have come in battered condition) with your name and address on the package, and send prepaid to the Michigan Book Binding Co., 1036 Beaubien St., Detroit, Mich. Send a copy of your letter of transmittal to the American Concrete Institute and a remittance of $1.75 (payable to the Institute) to pay the binding charge. The bound volume will be returned to you prepaid.

ADVANCE SPECIFICATION 502 TO STANDARD

ARTHUR R. LORD, author-chairman Committee 502, whose "Construction Specification for Concrete Work on Ordinary Buildings"* (502-30T) was published in the JOURNAL for November 1929 and tentatively adopted at the 26th Annual Convention last February, announces that the committee will at the next convention move its submission to letter ballot for adoption as standard. Further discussion will be in order at that time.

PROPOSED TENTATIVE SPECIFICATIONS

COMMITTEES originating the following specifications propose, at the convention, Feb. 1931, to move their tentative adoption:

"Specification for Supplying, Fabricating and Setting Reinforcing Steel on Ordinary Buildings," prepared by William F. Zabriskie, author-chairman Committee 503; published in the JOURNAL for February, 1930.†

*See A. C. I. *Proceedings*, Vol. 26, p. 1 and discussion, Vol. 26, p. 50 and Vol. 27, p. 99.

†A. C. I. *Proceedings*, Vol. 26, p. 444 and discussion p. 910.

"Construction Specification for Concrete Work on the Small Job," prepared by Arthur R. Lord, author-chairman Committee 506; published in the JOURNAL for September, 1930.*

"Specification for Ready - Mixed Concrete," prepared by Miles N. Clair, author-chairman Committee 504; published in its original form in the JOURNAL for February, 1930.† and in revised form in this issue.

NOMINATIONS ARE ALL RE-NOMINATIONS

NOTICE of the report of the Nominating Committee, nominating to succeed themselves all officers and three directors whose terms expire at the 1931 convention in Milwaukee, was mailed to members Oct. 25, as follows:

The Nominating Committee (chosen by letter-ballot of the membership as reported in October JOURNAL, *News Letter*, p. 7) reports the following nominations for offices to become vacant at the next convention:

President—Duff A. Abrams, Term 1 year.

Vice-President—S. C. Hollister, Term 2 years.

Treasurer—Harvey Whipple, Term, 1 year.

Director 3rd District—J. C. Pearson, Term 2 years.

Director 4th District—P. H. Bates, Term 2 years.

Director 5th District—F. R. McMillan, Term 2 years.

(Signed) NOMINATING COMMITTEE
A. E. Lindau, Chairman
E. D. Boyer F. H. Jackson
P. J. Freeman F. E. Richart

*A. C. I. *Proceedings*, Vol. 27, p. 65 and further discussion scheduled for the JOURNAL for January, 1931.

†A. C. I. *Proceedings*, Vol. 26, p. 467 and discussion p. 916; revised specification, Vol. 27, p. 281.

COMMITTEE NEWS

See also News Letter, Sept. 1930, p. 7

102—Volume Changes in Concrete—G. E. Troxell, chairman. Henry D. Dewell, San Francisco has been appointed and has accepted membership on the committee.

104—Permeability of Concrete—L. G. Lenhardt, author chairman, had prepared a digest of more than 200 typewritten pages of the literature and data of the subject. This is now being simmered down under his direction for a committee report summarizing available information.

107—Properties of Job - Cured Concrete at Early Ages—Harlan H. Edwards, author-chairman, is dividing the assignment by various fields of interest and experience and conducting a preliminary questionnaire as a basis for the organization of his committee with several sub-committee assignments. The report is to supply basic data as to safe form-work removal, road opening and products handling and related economic considerations.

108—Heat Developed in Concrete—Scope enlarged and title changed to **Properties of Mass Concrete**—Raymond E. Davis, chairman. Additions to membership of committee: F. W. Hanna, W. A. Perkins, G. E. Troxell, A. J. Wiley. A preliminary report summarizing available literature and data is in preparation and a formidable program looks just ahead for subsequent investigations and reports.

110—Use of Admixtures in Concrete—Ben Moreell, author-chairman. See call for data elsewhere in these pages.

111—Effect on Concrete of Repeated and Reversed Loads—H. H.

Scofield accepts author-chairmanship to prepare report in 1931.

112—Resistance of Concrete to Impact—W. M. Dunagan accepts author-chairmanship. Will prepare summary and develop new studies. The advisory committee's outline of the assignment: "Discuss: relation of this property of impact resistance to all other properties; effect of materials, w/c ratios, etc., effect of relation of mass of concrete to mass of impacting body; effect of velocity and momentum; effect of reinforcement; most effective type and distribution of reinforcement; actual impact conditions likely in practice—ships, buildings, roads, etc.

203—Cinders as an Aggregate for Concrete—Einar Christensen, author-chairman, has submitted the first draft of a monumental report. The critic members are next to have their inning, prior to publication.

308—Basis of Design for Hurricane Exposures — Albert Smith, author-chairman. D. C. Coyle, G. A. Maney and L. E. Ritter have been appointed and have accepted membership on the committee.

311—Moment of Inertia of Reinforced Concrete Members—F. E. Richart, author-chairman. M. B. Lagaard, G. A. Maney, Hale Sutherland and L. C. Urquhart have been appointed and have accepted membership on the committee.

312—Plain and Reinforced Concrete Arches—Charles S. Whitney has accepted the author-chairmanship of this new committee whose task is a major one. The Advisory committee's outline of the assignment:

"Discuss: Basis of all arch formulas for design; special features and advantages of various special sets of formulas; single and continuous arches; considerations arising from foundation conditions; effect of shrinkage, time yield, volume changes due to moisture and temperature; effect of modulus of elasticity of concrete; effect of weak concrete (wet batch or water-gain at various points; types of arches; effect of superstructure acting integrally with arch rings; economy of framing arrangements and in rise-span ratios; Freyssinet system, of fixing hinges after a period; Beggs' method of calculation from observations on models; details of reinforcement; wind action on arches; etc."

608—Sliding Formwork—L. Boyd Mercer, (Buenos Aires) has accepted the author-chairmanship of this new committee.

CEMENTS

SINCE THE Institute looks elsewhere for its cement standards the work being undertaken by Committee C-1 on Cement of the American Society for Testing Materials is interesting. The committee effected reorganization at a meeting in Washington, Sept. 5 and 6.

In the last year the Committee submitted a tentative specification for High Early Strength Portland Cement and an upward revision of the standards for Portland Cement. Both of these have been adopted by the A. S. T. M. and are now in effect.

With this new tentative standard and the revised standard in force, the committee believes that the opportunity is ripe for rather more fundamental and detailed studies of these two most widely used hydraulic cements, and of the masonry or plastic cements, whose use is growing so rapidly, than

was possible with the organization under which the committee had functioned for so many years.

The outstanding feature of the new plan of committee operation, places the investigations of each type of cement and the preparation of a standard under a separate subcommittee. For the present, therefore, there will be a subcommittee on Standard Portland Cement, one on Masonry Cement, and one on all High Early Strength Cements—both of the Portland and High Alumina type. Another subcommittee will have the duty of preparing the standards for methods of test. This subcommittee will not indicate to the other subcommittees what methods they should use, but rather will help the other subcommittees develop and refine the methods they think are needed to indicate the desired requirements, and further make as uniform and coordinated as possible the testing methods for all hydraulic cements.

In planning future work, the committee believed it desirable to throw off the shackles of precedent and past history. With two new standards just in effect, there is time at hand to make extensive studies of the sometimes considered radical new test methods suggested by progressive users and producers. It was not believed desirable to study any method or requirement simply because it was one of long-standing. Rather studies should be made of those requirements which are believed to be indicative of a needed property in the cement. Further, a needed property would be considered one which would indicate the department of the cement in use over a long period of time or under possible adverse conditions rather than that one which would indicate laboratory differences in cements.

The total membership of the committee is limited to 75, but it will welcome suggestions from all those interested in the testing and using of cement. The committee would be very glad to have comments as to the types of tests which should be studied, data indicating the adequacy or inadequacy of present methods, suggestions as to specific requirements, and in fact anything that an interested party would consider of value to the committee.

The committee will continue under the chairmanship of P. H. Bates, Bureau of Standards, Washington, D. C.; secretary, F. H. Jackson, U. S. Bureau of Public Roads, Washington, D. C.; and A. C. Tagge, Canada Cement Co., Ltd., Montreal and R. B. Young, Hydro-Electric Power Commission of Ontario, Toronto, as vice-chairman.

ADMIXTURES

WHAT DO *you know* about admixtures?

The question is asked in behalf of Lieut. Comdr. Ben Moreell, Civil Engineer Corps, United States Navy,* who has accepted the author-chairmanship of a new Institute Committee, 110, Use of Admixtures in Concrete.

His immediate job is to prepare a report summarizing available knowledge of the subject assigned.

This subject of admixtures is very broad. For the purpose of the present committee labor it embraces everything added to concrete (besides the

*Address: United States Navy Yard, Puget Sound, Washington.

essential ingredients—cement, water and aggregates) *in the mixer*, without restriction as to the object of the addition—whether as a waterproofer, to increase workability, or what not.

Such a committee labor was authorized by the Board of Direction almost two years ago. It took a year and a half to find a man of the right calibre to take on the job. In the opinion of the Advisory Committee, Commander Moreell's bravery does credit even to the United States Navy.

Will you assist? Send your data direct to the Author Chairman.

From among those who do assist and in the nature of whose assistance the most judicial mental attitude is apparent, some members of the committee will be selected.

The committee's assignment is difficult. It has many ramifications. There are bitterly opposed viewpoints. There is no yardstick for workability of generally acknowledged accuracy (several members of the Institute are working on this problem) and there is the insistent statement of some of the stoutest proponents of admixtures that their value cannot be demonstrated in the laboratory.

Despite the difficulties and meagre published data the work will be got actively under way about January 1. Commander Moreell expects to produce a preliminary report within a few months thereafter. More questions are probably asked about admixtures than about any other one subject in the field of concrete.

Many engineers have developed sufficient data to satisfy the need for some basis of guidance in their own practice. Some of these who have been unwilling to publish such meagre data may be willing to contribute it to the general hopper.

Commander Moreell suggests that producers of admixtures might well consult the Questionnaire for Admixture Salesmen (p. 13 of the *News Letter* in the January JOURNAL). Some few returns are available. Members, who can hardly be expected to have so complete data, may help greatly by sending in what they have. Fragments will be welcome. Producers are at liberty to urge users of their material to write of their use experience. Laboratories having facilities for research in this field are invited to contribute their accumulated results (credit will be given for all data used where credit is acceptable, and confidential information will be treated as such and used only in arriving at a sum-total.) Such laboratories should also state their capacity for additional research on this subject.

The subject is admittedly large and difficult and the committee must feel its way carefully in order that no injustice may be done. P. H. Bates says that the Questionnaire referred to cannot be satisfactorily answered even for portland cement. But the man on the job has to decide the issue and this committee proposes to give him the wisest counsel it can distill out of the material already in hand and to be gathered.

Some of the numerous materials have national distribution. Others are local or are used only for special results. It is probable they may all be grouped into a few classes and that the proper use of each class may be indicated by the assembled data. The conclusion may be negative as well as positive. Members having experiences in which concrete without admixtures has produced satisfactorily (expense and trouble considered) the results claimed for concrete with admixtures,

are invited to send in their data also.

Since the report will be of the author-chairman type, the chairman, after consultation with critic members of the committee to be appointed, will submit his first draft to his critics, for their thorough discussion. The committee-amended report will then be published for general discussion. Final revision will follow as soon as conditions (meaning the possibility of a more exhaustive and thorough-going test program, than has thus far been undertaken) make this possible.

DISINTEGRATION OF CONCRETE AND ITS PREVENTION*

BY B. KELLAM†

By Dr. Ostendorf, Münster, Westphalia, gives a description in *Bautechnick*, Volume 7, pages 435-8, 1929, of an interesting case of concrete disintegration.

It concerns a sloping, supporting wall of reinforced concrete about 325 ft. long, 26 ft. high, a base of 14½ ft., ribbed, and with plenty of internal reinforcement. In building the wall, a mix of the following proportions was used: 1 cement, 0.5 Trass and 8 gravel-sand. The latter was not added separately, but just as it was dredged from the Rhine. On the port side, the wall was finished with a smooth coat, while at the rear it was given a 1:2 plaster coat of cement and Rhine sand, and then coated with a layer of tar. The level of the ground water behind this quay wall was about a foot higher than the harbor, resulting in a constant difference in pressure from back to front. The ground water contained from 300 to 400 parts per million of SO_3.

On investigation it was shown that the back fill contained pockets of marshy earth, and that the surrounding territory was stratified with layers of mud, the latter rich in sulfates. It was observed that the ground water tended to flow through these layers toward the wall, thus continually dissolving out fresh sulfate compounds which were deposited in the wall. Despite the coat of plaster and tar, the disintegration of the concrete was so marked that it could be removed with a scoop, leaving a cleanly-cut section as though cut in soft clay. With a rod, the wall could be pierced from front to back. There were holes bitten deep in the outer face of the wall whose dimensions would need to be noted in square feet. The reinforcements were very much rusted and gave no strength to the concrete.

On examining the attacked concrete, two phases could be distinguished. The first was made up of a grayish-white material, the second yellow Both phases blended off into each other. A comparison of the analysis of these two phases with the average analysis of the remaining sound concrete indicated the cause of the disintegration. The grayish-white material showed a significantly greater content of SO_3 than the sound concrete, the content of SiO_2 and Al_2O_3 being lowered. It is the latter two compounds which, in combination with CaO, hold the sound concrete together and endow it with strength. Through salts of sulphuric acid, the compounds of CaO, SiO_2 and Al_2O_3 are destroyed. In their place is

*This interesting abstract would ordinarily have been reported in the *Abstracts* pages but the original was published prior to the period covered in the inauguration of Institute Abstracts.—EDITOR

†Asst. Chemist, Hydro-Electric Power Commission of Ontario.

formed a compound of sulphuric acid, CaO and Al_2O_3 known as calcium sulphaluminate. This compound exists in the form of crystals in the cavities of the concrete, and on crystallization increases greatly in volume by the absorption of water. Due to the increasing pressure of the growing crystals, the concrete is forced open forming additional fissures and cracks. The aggressive ground water, forcing its way in, is given increasingly more room for action and more surface to attack. Thus the destruction continues until all cohesion of sand and gravel is destroyed.

The analysis of the soft yellow concrete indicated a content of lime, silica and alumina much lower than in sound concrete. The SO_3 content, however, was lower than in the grayish-white material. Since it has been shown that the SO_3 was the cause of the disintegration, this apparent contradiction is explained by the fact that the crystals of calcium sulphaluminate are soluble in water and are carried away in solution by the flowing ground water. Finally, all that is left of the concrete is sand and gravel which takes on a yellow color due to the iron hydroxide contained in the ground water.

The phenomena of disintegration in this case are to be traced to the sulphate-containing water, assisted by capillary action and thereby accelerating the destruction. The disintegration of the concrete in the tamped joints shows that the permeability of the concrete at these joints was unusually great.

The 27th Annual Convention —Milwaukee, is little more than 3 months away—Feb. 24-25-26.

A. C. I. MEMBERS

L. C. URQUHART and C. E. O'ROURKE

respectively, professor and assistant professor of Structural Engineering at Cornell University, authors of "Design of Concrete Structures" (McGraw-Hill, 1923-26) have produced a companion volume, "Design of Steel Structures," from the same publishers. Professor Urquhart is a member of Committee 311, Moment of Inertia of Reinforced Concrete Members and 501, Standard Building Code.

T. C. POWERS

who wrote "Concrete Studies at the Bull Run Dam" (A. C. I., Vol. 25) and with which work he was identified for the Bureau of Water Works, Portland, Ore.; recently concrete technologist for the Readymix Concrete Co., 210 Thompson St., Portland, is now Associate Engineer of the Portland Cement Association, 33 West Grand Ave., Chicago. Mr. Powers is a member of Committee 504, Specifications for Ready-Mixed Concrete.

E. R. EVANS

Civil Engineer with the Canadian National Railways, formerly at Halifax, Nova Scotia, has been transferred to the Chief Engineer's Office at Moncton, N. B.

GEORGE B. SOWERS

formerly Deputy Commissioner of the Division of Engineering and Construction of the City of Cleveland, has been advanced to Commissioner.

LEVON SERON

formerly architectural Engineer for Granger & Bollenbacher, Chicago, has returned to the Massachusetts Institute of Technology for a post-graduate course in architectural engineering, majoring in reinforced concrete design and testing. Mr. Seron's address is 11 Inman St., Cambridge, Mass.

FRANK X. KOLB

whose love of gardens and flowers took him out of the wholesale and retail meat business 15 years ago into the manufacture of concrete garden furniture, died October 10 at his home in Detroit after a short illness. He was a familiar figure at Institute conventions of recent years. His alertness to improved methods and designs and his insistance upon an unvarying integrity of workmanship had put his products into many beautiful gardens of Michigan and won him a host of friends in the fraternity of gardeners.

READY-MIXED CONCRETE

J. E. BURKE, president the National Ready Mixed Concrete Association, 27 Barbeau St., Pittsburgh, Pa., extends to interested members of the American Concrete Institute an invitation to attend his association's convention at the New Hotel Jefferson, St. Louis, Mo., January 26, 1931.

27th Annual Convention Milwaukee February 24–26, 1931

IN CONSTANT REPAIR

(A Conversation with Dr. Sam'l Johnson)

Dr. Johnson: A man, Sir, should keep his Friendships in a state of Constant Repair.

The Author: And no less, Sir, his Information.

9. SURPRISING RESULTS

BY ARTHUR R. LORD

A MEMBER of the Institute from South Africa, writing, not exactly in this column, but next door to it surely, released a sentence that rejoiced me exceedingly. I recognized in him a kindred spirit. "I frequently try out ideas of other people and myself for improving things and get surprising results." Isn't that delicious? Such things make life interesting, at times even exciting, for the concrete specialist.

I am often called in when other people achieve "surprising results" so that I get to enjoy their surprises as well as my own. Most of my surprises have been pleasant. I trust that I appeared sufficiently nonchalant when concrete from Wacker Drive, cut out for the Wabash Ave. bridge, tested at better than 10,000 lb. per sq. in.,* but, truth to tell, I was delightfully surprised. That seemed fairly remarkable, using 6.5 gallons of water to the sack of cement, placed in zero temperatures, even if the concrete was nearly four years old at the time of testing. How much more exciting it must have been for the Benedict people to have their 4¼ gal.-per-sack Haydite concrete test at the same figure at only six weeks! Does vibration put more Abrams yeast into concrete—make it

*Five thousand to 6,000 lb. per sq. in. would have satisfied Mr. Abrams in either case.

increase in strength much faster than our usual field experience shows? Mr. Mair did not say whether his surprises were happy or otherwise, but I trust they may have been. Being a member of the Institute, zealously endeavoring to perfect his technique, he deserves pleasant surprises.

I imagine that not a few folks were surprised when, endeavoring to measure the water-tightening effect of a certain admixture on concrete, it was found that all of the common mixes included in the series were highly watertight without any assistance from admixtures. Probably the gentleman who was paying for an extensive investigation of this admixture was impressed by these "surprising results." I hope that he went back to his field superintendents and told them that a most successful series of tests had been completed—that now he knew, when concrete was leaky, they were to blame!† Then it was their turn to be surprised, possibly dismayed. They may even have done something about it.

What a wallop may be packed into those two words upon occasion! Think of what happened to certain curing coatings, that showed just about perfect in the laboratory, when they were applied under a boiling Southern sun!‡ It seems that I can recall a concrete construction or two that prospered exceedingly until some fool Professor was paid by the promoter to put on a test load somewhat larger than the usual working load. Painful surprises in concrete, so far as I have observed, may readily be avoided by sticking to the well-marked paths. But when you try out the ideas of other people and yourself, as Mr. Mair rashly proposes, you must look for surprising results on both sides of the X-axis. Faithfully reported, they may do much to keep our information in a state of Constant Repair.

†This ought to convince the admixture people that I am exceedingly hostile. Really I am on the fence, ready to flop to their side, if they would give me any valid excuse, such as a real set of scientifically planned tests.

‡Since Professor Gilkey worries about my question marks, I'll use a few exclamation points instead. They will be less likely to stick. But I refuse to suppress all curly-queues.

10. NEW RUSSIA, SECOND HAND

BY ARTHUR R. LORD

I WONDER how many members of the Institute share my intense and complete bewilderment as to the true condition of affairs in Russia. That alone should qualify me to write of that strange new form of government. You can readily imagine, therefore, the hilarious enthusiasm with which I welcomed the return of a member of the Institute who has been two years in Russia. I laid up an amazing supply of question marks and prepared for a bully time. This returned member had been associated with me on Wacker Drive. Although born in Russia, he carries an American training and education. He is here on furlough, so to speak, from his job as an American inspector and advisor on Russian building construction. Let me impart to you some small fraction of the new information under which my mental shelves now groan.

Imagine for a moment that you are transported or translated to the new Russia and that you propose to carry on your regular work of building construction. How great would be the change? The first slight adjustment is required by the fact that in Russia, the landowner, the building owner, the banker, the architect, the engineer, the

contractor, the sub-contractor, the material dealer and the laborer are all theoretically one—the new Russian government. An exception to some of this occurs when a group of individuals in the same recognized class wish to erect a cooperative apartment for their personal use. This initiative the government welcomes. It permits you to occupy the land without expense. It makes the loan to complete the financing of the project, at very small interest.

If you wish to build a factory or a theatre or an office building—you are just out of luck. The government decides when such structures are needed and how they shall be built. All industrial and building activity is outlined by the Government Planning Commission and allocated to "trusts." All chemicals are manufactured by a certain trust, the name of which I have heard. Fords are made by another trust. Buildings are planned by one trust, erected by another, from materials supplied by a third, and are equipped with heating, plumbing, etc., by a fourth. There may be several trusts in the same field of activity, grouped in certain territories and controlled by their central master trust in Moscow.

Each industrial trust receives from the government notice of the amount of money it will have to spend on buildings over a period of years. Russia just now, is engaged in a tremendous expansion of its heavy manufacturing facilities. The appropriation determined, each trust lays out its building program for the year ahead in accordance with the central plan. This is then approved by the proper office of the government, which authorizes the design trust to produce a set of plans, the material trust to get out the necessary cement, sand, gravel, etc., for the work, the building trust to organize the construction equipment and forces, the government unions to arrange for the necessary labor, and so on. All these agencies move to the attack simultaneously, knowing from past experience what their part of the work must cost, out of the total available. Generally things move along smoothly, ever more smoothly as experience is accumulated. You may have 300 carpenters arrive three weeks before you need them, but that can be adjusted, since under such emergencies a carpenter can do other things. The system works. And you work for the government instead of for yourself.

If you are employed in the design trust you do your day's work for a day's pay the same as any other citizen. Your house rent, for the same quarters in modern, government owned apartments, is determined by your salary scale. Your wife works. When the baby arrives, she has the necessary time off with full pay, but she goes back to work when her strength is restored fully, and the government provides the care for the baby by day. All medical service is free. You eat in the common dining room, although you may serve small refreshments in your apartment. At the office, you soon accustom yourself to the use of the metric system, as anywhere on the continent, and to Russian notes and lettering. Bar sizes, strangely, are based on fractions of an inch, and so designated on the drawings interchangeably with the metric equivalents. But the Russian engineer is not acquainted with the foot. He will cheerfully go inches with you, but after that, meters only. Small bars—¼-in.

bars round and sometimes ⅜-in bars round—arrive on the job in immense coils, several hundred feet long. Larger bars in the past have come only in short lengths, such that every bar must be spliced at least once in every beam and column. f_s is 1200 kg/cm.² Spirals are made on the job, when used at all. For unknown reasons, admixtures have not yet arrived on the Russian scene. The German influence in design is predominant, but is fast being superseded by American practice.

In every trust there is a Rationalization Department, which the Institute might well copy. Russia has gathered ideas the world over, is constantly acquiring new ones. This department sorts them out for its particular field and seeks to standardize on that which is best suited to Russian economy and efficiency. The Technical Aid Society instructs the working man in the best ways of handling himself and his materials. This is headed by Lenin's sister. The A. C. I. Concrete Primer has been reprinted in Russian and distributed by this society. The writings of Abrams have become a part of Russian technical literature.

There seems to be a lot of ordinary common sense mixed up with the uncommon practices of Russia. My friend at least is most enthusiastic, is looking forward eagerly to his return. Just now he is collecting American ideas for a return cargo. Pamphlets, drawings, photographs of anything new and efficient will be cheerfully accepted. If we do not bring back some important new contribution for America, from all this investment abroad, I shall be greatly surprised.

BUILDING UNITS OF STANDARD (?) SIZES

FROM A LETTER BY BENJAMIN WILK*

IF STANDARDIZATION in masonry units is to be effective it is necessary that all manufacturers be guided by the rules of the standardization committee. The national standards for brick call for units 2¼ in. high. On the basis of this dimension concrete building tile were set at 5½ in. high so that one concrete building tile is equivalent in height to two standard brick plus a ½ in. mortar joint.

In the Detroit market the common brick manufacturers produce a unit 2½ in. high. This makes it necessary for the concrete tile manufacturers to make a unit 5½ in. high to be equivalent to two brick plus ½ in. mortar joint. The 5½-in. tile is not a recognized standard. Face brick coming into the Detroit market are generally 2¼ in. high. In order to get concrete tile to bond properly with face brick, concrete tile must be made 5 in. high. Very little progress can be made in eliminating sizes of masonry units if manufacturers in different communities insist on varying dimensions of the products from the standards as set by the standardization committee of the U. S. Government.†

*General Manager. Standard Building Units Corp., Detroit.

†As a matter of fact the manufacturers and users made their own standards in cooperation with the U. S. Dept. of Commerce. A government bureau did not force anything on them. —EDITOR

See Notice About Binding Your JOURNALS, Page 3

NEW MEMBERS

FIFTEEN applicants for membership in September 1930 have been approved by the Board of Direction as follows:

Anderson, W. R., Fairfax Bldg., Kansas City, Mo.

Bedford Construction Co., 333 N. Michigan Ave., Chicago, Ill. (N. H. McKenzie)

Bruner, Louis S., 20 S. 36th St., Philadelphia, Pa.

Cline, L. A., 1013 No. Sycamore, Los Angeles, Calif.

Florida Portland Cement Co., P. O. Box 1075, Tampa, Fla. (Cyrus N. Wells)

Frolich, A. K., Ash Grove Lime & Portland Cement Co., Louisville, Nebr.

Gardner, Guy O., Ash Grove Lime & Portland Cement Co., Chanute, Kansas.

Hanna, Frank W., 512 16th St., Oakland, Calif.

Large, George E., 776 S. Remington Road, Columbus, Ohio.

Osborn Co., C. J., 132 Nassau St., New York, N. Y. (W. F. Purdy)

Reynolds, Frank L., Irons & Hoover, Inc., 420 Lexington Ave., New York, N. Y.

Rockwell, J. A., 321 Sunderland Bldg., Omaha, Nebr.

St. Joseph Cinder Block Co., St. Joseph, Mo. (Robert Brown)

Universal Atlas Cement Co., 642 Brown Marx Bldg., Birmingham, Ala. (J. C. Meacham)

Vago, Oscar J., 2820 37th St., Long Island City, N. Y.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC. REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

Of Journal of the American Concrete Institute published monthly except July and August at Detroit, Mich., for October, 1930.

State of Michigan } ss.
County of Wayne }

Before me, a notary public in and for the State and county aforesaid, personally appeared Harvey Whipple, who, having been duly sworn according to law, deposes and says that he is the Editor of the Journal of the American Concrete Institute and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912 embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, American Concrete Institute, 2970 W. Grand Blvd., Detroit Mich.; Editor, Harvey Whipple, 2970 W. Grand Blvd., Detroit, Mich.; Managing Editor, none; Business Manager, none.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, must be given.) American Concrete Institute, 2970 W. Grand Blvd., Detroit, Mich.

Duff A. Abrams, President, 342 Madison Ave., New York, N. Y.

S. C. Hollister, Vice-President, Purdue University, Lafayette, Ind.

Arthur R. Lord, Vice-President, 140 So. Dearborn St., Chicago, Ill.

Harvey Whipple, Secretary-Treasurer, 2970 West Grand Blvd., Detroit, Mich.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stocks, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is ——. (This information is required from daily publications only.)

HARVEY WHIPPLE.

Sworn to and subscribed before me this 2nd day of October, 1930.

(SEAL) ETHEL BLAINE WILSON.

(My commission expires July 30, 1934.)

Papers and Reports—In this Issue

Proceedings American Concrete Institute

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Publication of discussion of the contributions in the following pages is on a time schedule. Please see inside cover pages.

Architectural Concrete—Forms, Molds and Surfaces

BY WILLIAM C. WAGNER*

Architecturally treated, exposed concrete as an exterior finish for buildings is a comparatively recent adaptation of the material, that requires, in addition to purely structural qualities, a smooth, durable finish and a definite sharpness of detail comparable to cut stone or carving. In our efforts to obtain the most satisfactory surfaces with this medium, we have revised many of our former opinions and extended our study to all agents and accessories that contribute to a concrete structure, for the uncertainty of success and the finality of the result make extreme care in preparation a mandatory consideration. Although the work is complicated by the nature of the material which places many limiting conditions on its uses, many of the faults of exposed concrete can either be eliminated or provided for by well studied design.

In building forms for architectural concrete there is no radical departure from the practice accepted for structural concrete, unless it be that they are lined with materials that control the character of the resultant surface. This discussion will therefore be confined to these materials and such variations from usual practice as are required to yield a satisfactory finish. Subsequent remarks may not receive complete concurrence from all who work with exposed concrete, because of such difference of opinion on the various points of procedure as result naturally from individual experience.

In a broad sense there are three types of wall treatment encountered in buildings—plain, ornamented and molded surfaces——each of which required a different type of form lining.

*Morgan, Walls & Clements, Architects, Los Angeles, Calif.

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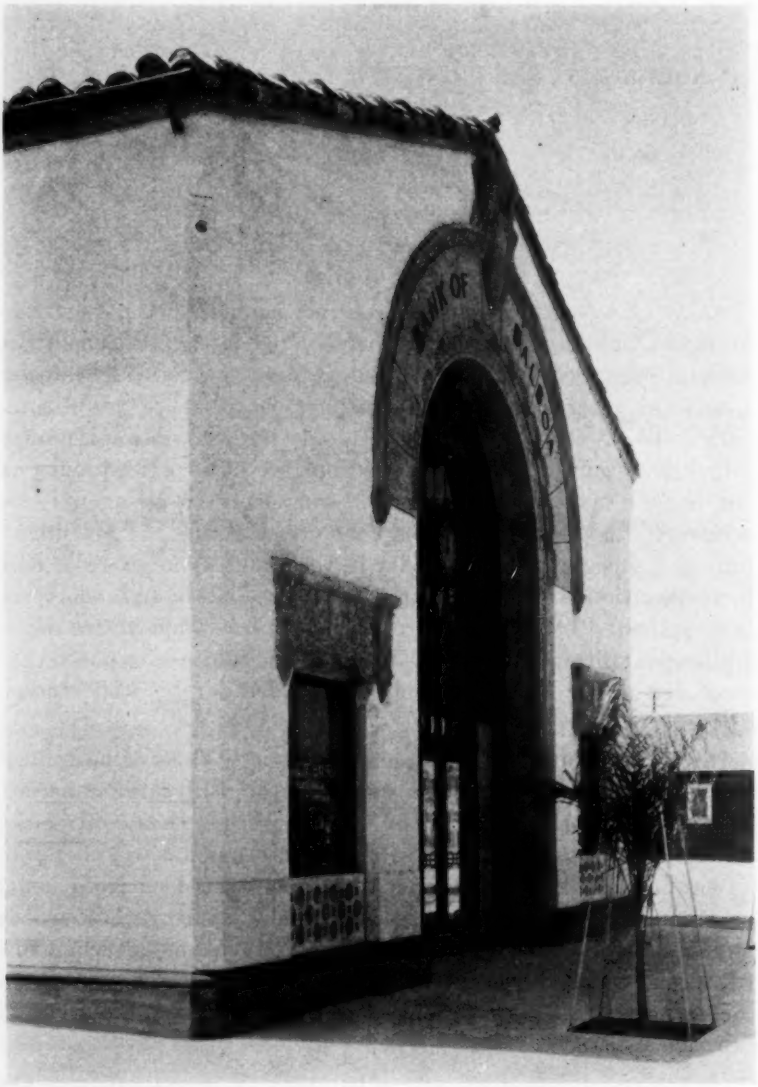

FIG. 1—BANK OF BALBOA, BALBOA, CALIFORNIA—MORGAN, WALLS AND CLEMENTS, ARCHITECTS, LOS ANGELES. AN EARLY EXAMPLE OF EXPOSED CONCRETE STRUCTURE EMPLOYING PLASTER WASTE MOLDS AND ORDINARY BOARD FORMS

LINED FORMS FOR PLAIN SURFACES

For plain surfaces, forms are lined with a board of fibrous composition or with built-up wood panels, generally of three-ply construction and for ornamented and molded surfaces plaster casts and wood patterns are used.

To provide a rigid frame for attaching these linings, it is advisable to use 2-in stock. The use of 1-in. stock is questionable economy, because to overcome its tendency to buckle, more extensive bracing is necessary, with consequent additional expense of material and labor.

Fibre board is produced in large sheets which can be readily sawn to size; it is rigid and light in weight and it is easily nailed to forms or drilled to allow the passage of tie wires. Since its smooth surface is almost entirely impervious to water, it is neither necessary nor advisable to attempt a waterproofing treatment. The application of shellac has been tried with the result that when the forms were stripped, the shellac adhered to the concrete and peeled the surface from the fibre board. This was removed from the concrete with great difficulty.

When adjoining sheets of fibre board are butted tight water will cause the edges to rise and leave depressions in the concrete. Where design requires joints to suggest stone, this characteristic can be used to advantage by cutting the fibre board to the required stone sizes. If no joints are desired, such depressions can be prevented by allowing an expansion gap of not more than $\frac{1}{8}$ in. for full sheets. This gap will leave a small cement fin which can be brushed off easily and with no damage to the surface. Further precaution against surface marring can be taken by burnishing all edges that occur at exterior angles, by driving all nails flush only and by nailing the fibre board to the same form board wherever practicable. In instances where nails have been staggered the action of the form boards has been sufficiently opposite to cause the fibre board to buckle and leave a wavy concrete surface. Depending on the length of time it remains in the forms, fibre board is likely to lose its smooth surface and some of its rigidity, so that the advisability of using it for more than one pour will depend on its condition when released from the forms.

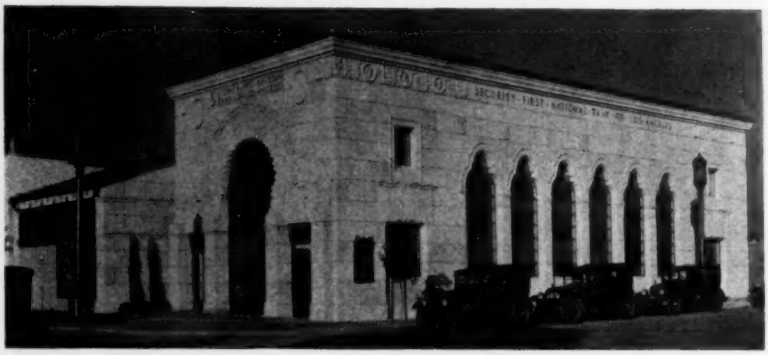

FIG. 2—WESTWOOD BRANCH, SECURITY-FIRST NATIONAL BANK OF LOS ANGELES—MORGAN, WALLS AND CLEMENTS, ARCHITECTS

WOOD FORMS

Except for occasional impressions from raised grain and the absence of fins and joint depressions, the surfaces obtained by the use of wood panels are comparable in texture to those resulting from fibre board. Grain impressions are not usually deep enough to be noticeable except in bright sunlight, but if they are objectionable the grain can be sealed. However, this might be relatively expensive, since the precaution is not necessary in the use of fibre board. When the edges of wood panels are planed smooth and butted tight there is no resultant swelling and it is not necessary to allow an expansion gap between panels. Therefore depressed joints can be obtained in one pouring operation only through the introduction of wood strips cut to required width of the stone joints. The advisability of using the same panels for subsequent pours can again be decided by their condition when stripped from the forms.

All wood milled for form lining should be as smooth as possible, kiln dried and entirely free of loose knots or other defects. Probably the best wood for this purpose is California white pine—generally called sugar pine—and eastern white pine because their uniform grain has a negligible tendency to rise under the action of water. Due to the compactness of the grain, waterproofing is sometimes not necessary for these woods. However,

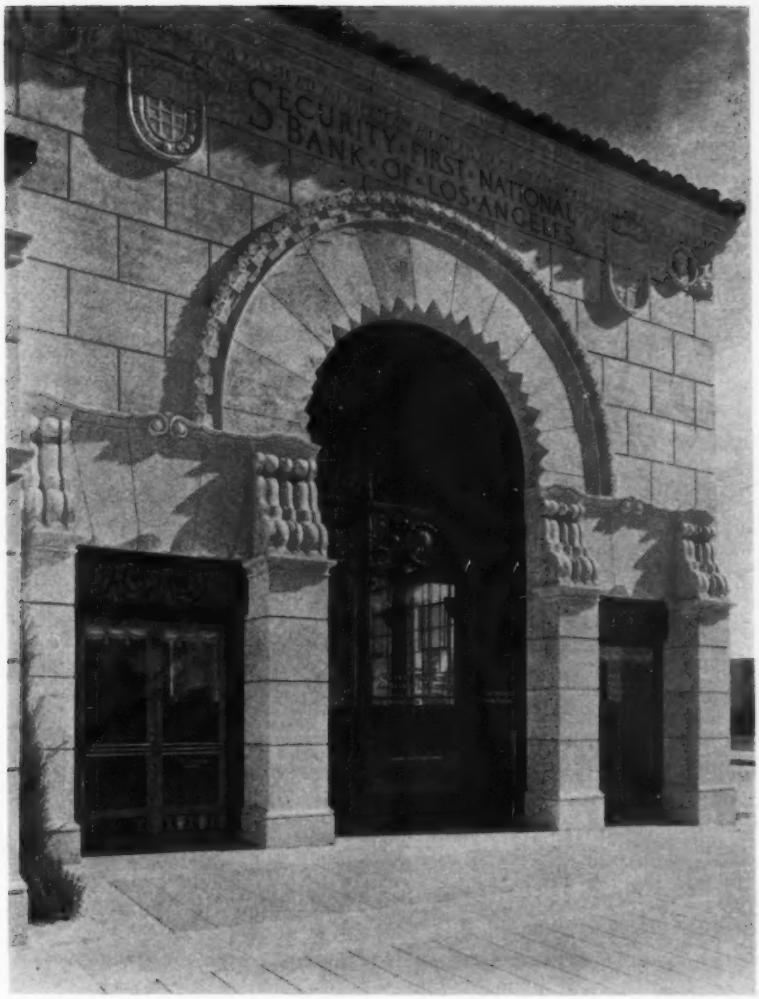

FIG. 3—DETAIL OF WESTWOOD BRANCH BANK. A RECENT STRUCTURE FOR WHICH FIBRE-BOARD LINED FORMS AND PLASTER MOLDS WERE USED

they are soft and care must be taken not to damage their surfaces in puddling operations.

Paste fillers or shellac and varnish as seals for wood grain are not as satisfactory as lead and oil, because of the difficulty of obtaining a permanent bond that will prevent adhesion to the concrete. Since inferior grades have been known to stain concrete, a high grade of lead and oil should be used and unless the wood is painted on all faces, the water from curing operations will raise the grain by seeping under the lead and oil from the unprotected surfaces. If care is taken in stripping, wood molds can be cleaned and used for subsequent pours according to the repetition of detail.

PLASTER MOLDS

The term waste-molds is a descriptive designation of the plaster molds that are used to obtain ornamented surfaces and that are broken in stripping the forms—wasted so to speak. The amount of damage done to plaster molds in stripping depends on the nature of the ornament, and the extent of undercutting, but in no case can they be removed in a condition suitable for re-use—in fact they sometimes have to be chopped from the concrete. Only in instances where the design is extremely simple is there a possibility of stripping plaster molds without serious damage; and where the design presents such simplicity the molds would doubtless be wood.

From the approved clay models made under the Architects' supervision, plaster reverse molds are made. They are reinforced where necessary, and fitted with wood ties and bracing for building into the forms. In order to prevent the collapse of waste molds under the pressure of the concrete, it is advisable that they be not less than 1 in. thick at any point. Where a number of identical waste molds are required by the repetition of ornament, they are obtained by the use of a glue mold made from the reverse plaster mold. For safety in shipping, plaster molds should be well packed in sawdust.

Unless plaster molds are sized or fixed to prevent the absorption of moisture from the concrete, they may disintegrate and destroy the ornament, or the concrete may soften, spall and leave a rough surface. The application of two coats of thin shellac

has been found the best and cheapest method of sealing plaster molds and while there are several other methods used in an attempt at economy, there is none as simple or efficient as the use of shellac. A mixture of gasoline and melted paraffin which is sometimes used as a substitute for one coat of shellac, seals the mold when the gasoline evaporates and leaves only the paraffin in the pores. One coat of shellac is required after this operation. The difficulty of using the gasoline mixture lies in the fact that the gasoline must be luke warm in order not to congeal the melted

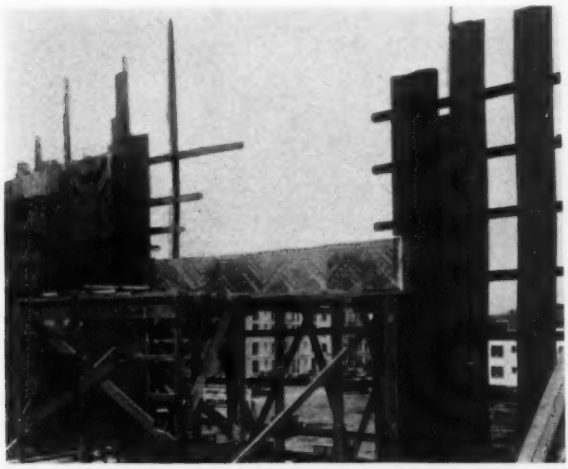

FIG. 4—PLASTER WASTE MOLD SET IN PLACE

paraffin—and heating gasoline is not the safest of operations. There has also been some experimentation with slightly colored lacquer as a substitute for the initial coat of shellac. However, since the best results have been obtained with shellac and inasmuch as one coat of thin shellac has always been required to complete the waterproofing, it seems advisable to use shellac as the sole fixing agent.

Wherever pointing or patching of any kind is necessary for any type of form the best agent is a mixture of plaster of paris and shellac. This mixture sets quickly and leave a hard, tough

surface that can be sand papered, filed or polished, according to the nature of the surface desired.

OILING FORMS AND MOLDS

After the lining materials have been installed in the form work, they must be oiled to simplify stripping. Wood

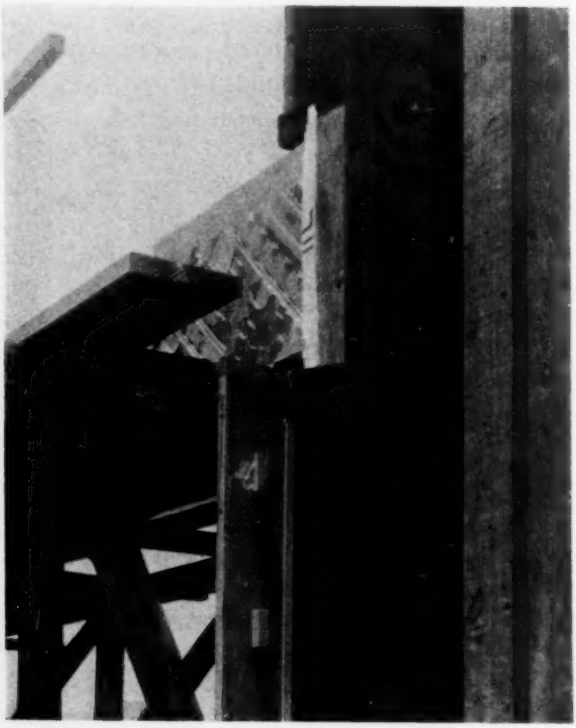

FIG. 5—FORMS PARTIALLY LINED WITH FIBRE BOARD

molds that are not painted are given a coat of standard liquid form oil which soaks into the wood and requires no further attention. All lining throughout is next greased with a form oil that has a consistency of cup grease and finally wiped as clean as possible with rags, for any excess oil will cause unsightly stains on the finished surface.

Numerous methods are used with uniform success in greasing waste molds and which employ all kinds of lubricants from cylinder oil to cup grease. In one case cup grease is thinned to the point where it can be applied with a brush, by the addition of a mixture of crystallized stearic acid and a small quantity of kerosene.

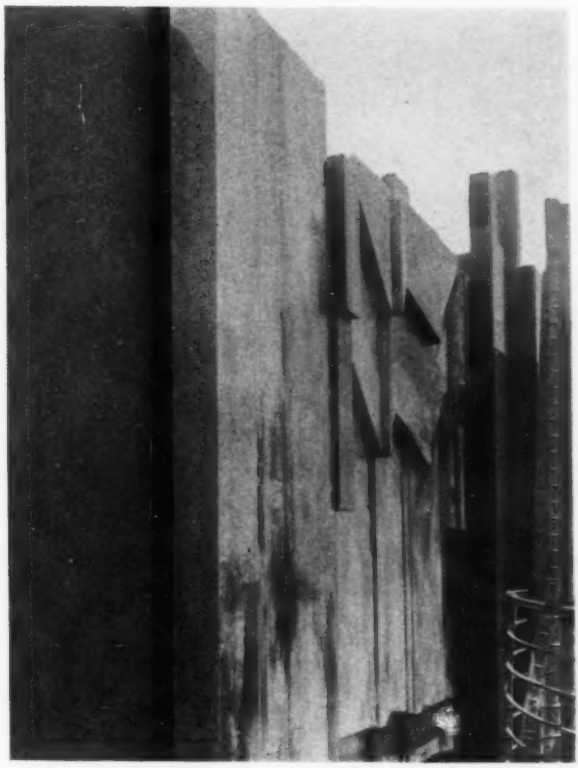

FIG. 6—WASTE MOLDS AND FIBRE BOARD IN PLACE

For anchoring the two sides of the form work, pencil wire ties equipped with collars and set screws are preferred to bolts, because they can be removed with less damage to the concrete. The tendency of such wire to stretch under pressure can be overcome by proper spacing of the ties according to conditions.

CONCRETE MIXTURES

The study of the various concrete ingredients and their proportions in the mixture is the most important step in developing satisfactory exposed concrete surfaces, because it controls the workability and the limits of adaptability of the concrete to

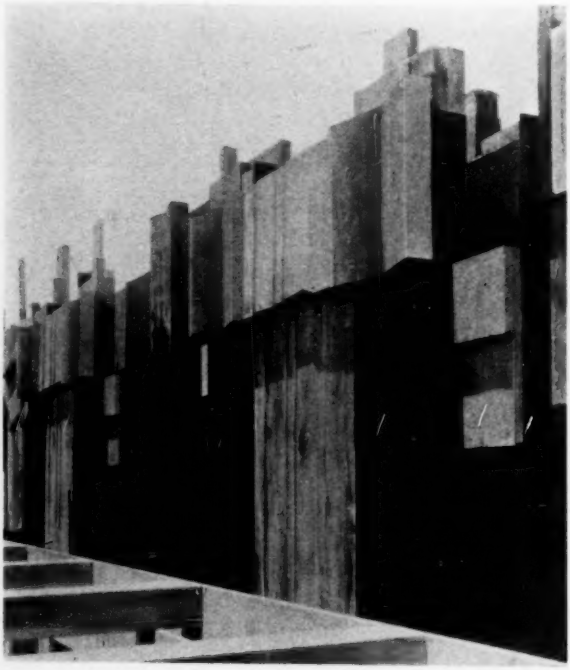

FIG. 7—WASTE MOLDS, FIBRE BOARD AND WOOD MOLDS IN PLACE

conditions of forms and ornament. Concrete control embraces the selection of aggregates, cement, sand, admixtures and water, and the testing of these materials in combination and for impurities.

The proportions of ingredients in the concrete mixture will be established by local building ordinances and by the water-cement ratio established for the developed strength required in the concrete. It seems a universal tendency to place concrete too wet and since excessive water is ruinous to concrete surfaces,

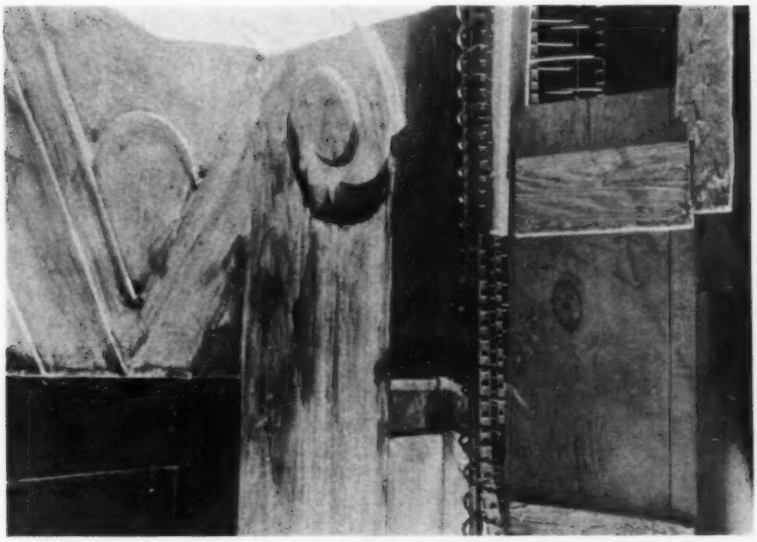

FIG. 8—WASTE MOLD IN PLACE

great care must be taken to prevent a surplus of water. The success of the concrete finish is dependent upon the proper suspension of the materials. A minimum of water helps to prevent the weakening of concrete and the formation of rock pockets and voids. There are conditions of difficult placing such as undercutting in waste molds or projections beyond the normal wall faces that demand a mixture of greater water content for proper workability, but this extra water is offset by a corresponding increase in cement. In all such cases of enriched mixtures, slump tests will determine the limits of richness. For plain surfaces proper workability requires a slump of approximately 4¾ in. in a specimen cone of a 6-in. diameter and 12-in. high. For varying conditions a mixture with as much as a 7-in. to 8-in. slump is often necessary. Similarly the concrete may vary from a mixture of 1 cement to 2½ sand, to 3½ rock or gravel, to a mixture of 1:3:3 or richer. For acceptance the concrete must develop a compressive strength of not less than 2000 lbs. per sq. in. in 28 days. Conditional acceptance at a seven day period

requires not less than 900 lbs. per sq. in. A survey of a series of tests shows that for a slump of 7-in. to 8-in. the concrete has developed compressive strengths that vary from 1000 to 1800 lb. per sq. in. after 7 days.

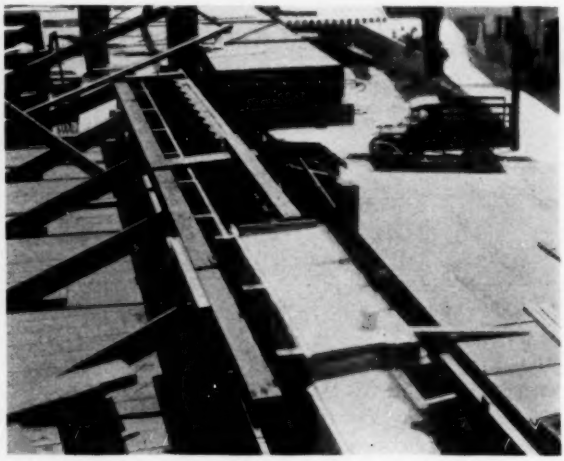

FIG. 9—CONCRETE PLACED AGAINST WOOD MOLDS

ADMIXTURES

Numerous properties are claimed for various concrete admixtures, among which are the tendencies to increase the workability of the mixture and to prevent efflorescence. From the standpoint of workability and finish alone, we have recently obtained more satisfactory surfaces by substituting an equivalent amount of extra cement for the admixture previously used. However, we do not necessarily subscribe to the idea that the use of admixtures should be abandoned for there is no doubt that they tend to increase the strength and durability of concrete, and admixtures which change the structure of hydrated lime are effective preventives of efflorescence. Other steps to prevent efflorescence are the usual rigid specifications governing the properties of the cement, sand, aggregate and water.

FIG. 10—TYPICAL ARCHITECTURAL CONCPETE SURFACE SHOWING WIRE AND MINUTE AIR HOLES AND DEPRESSION FROM A FIBRE BOARD JOINT

PLACING CONCRETE

Before concrete is deposited all debris and drippings should be removed and the forms should be thoroughly wetted. To insure a uniformity of surface texture, the concrete should be transported as rapidly as practicable and as near as possible to its final position to avoid rehandling and so placed in the forms that no separation will occur. It should be deposited in continuous horizontal layers with a difference in levels not greater than 18 in., in order that there be a minimum flow of the concrete. Throughout the placing operations the concrete should be assisted into place by constant puddling to insure a uniform filling of all voids and an elimination of rock and air pockets by forcing air and excess water to rise to the top of the pour. By tapping the form boards the sand and cement are drawn to the

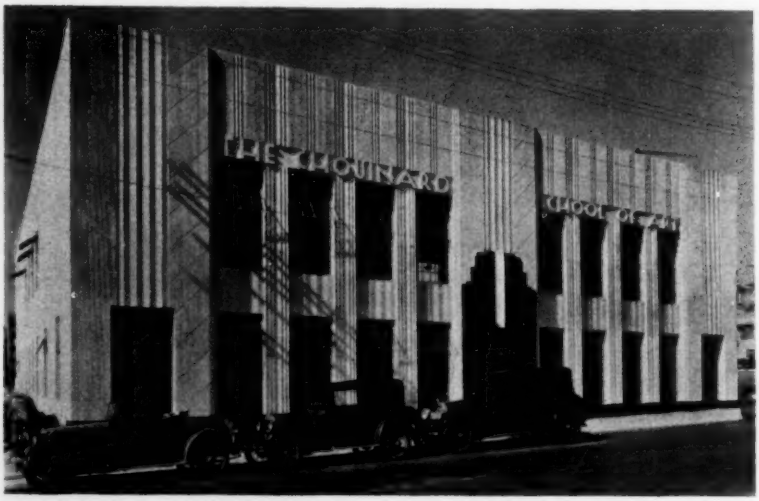

FIG. 11—CHOUINARD SCHOOL OF ART, LOS ANGELES—MORGAN, WALLS AND CLEMENTS, ARCHITECTS

outside of the wall and produce a smooth surface free from exposed aggregate. For agitating the concrete during the pour, puddling with wood strips is a safer operation than spading, because there is less opportunity to cut wire ties or to mar the surface of the form lining.

When it has been determined where the pour is to stop a wood strip is tacked to the forms at the outside surface of the concrete wall. The pour is carried about ½ in. above the underside of the strip and sloped to the inside face so that laitance and excess water will drain to the inside face of the concrete which will be cleaned and plastered. About an hour later the strip should be removed and the concrete leveled off with a steel trowel so that any demarcation between the subsequent pour will be a straight line and therefore least noticeable.

STRIPPING FORMS

Forms should ordinarily remain five to seven days before stripping and during this time the form work for the next pour is constructed. Before the next higher pour is made, the bottom

FIG. 12—CONCRETE WAS PLACED AGAINST MILLED WOOD FORMS AND SURFACES THROUGHOUT BRUSHED WITH CEMENT WASH AS FINISHING MATERIAL

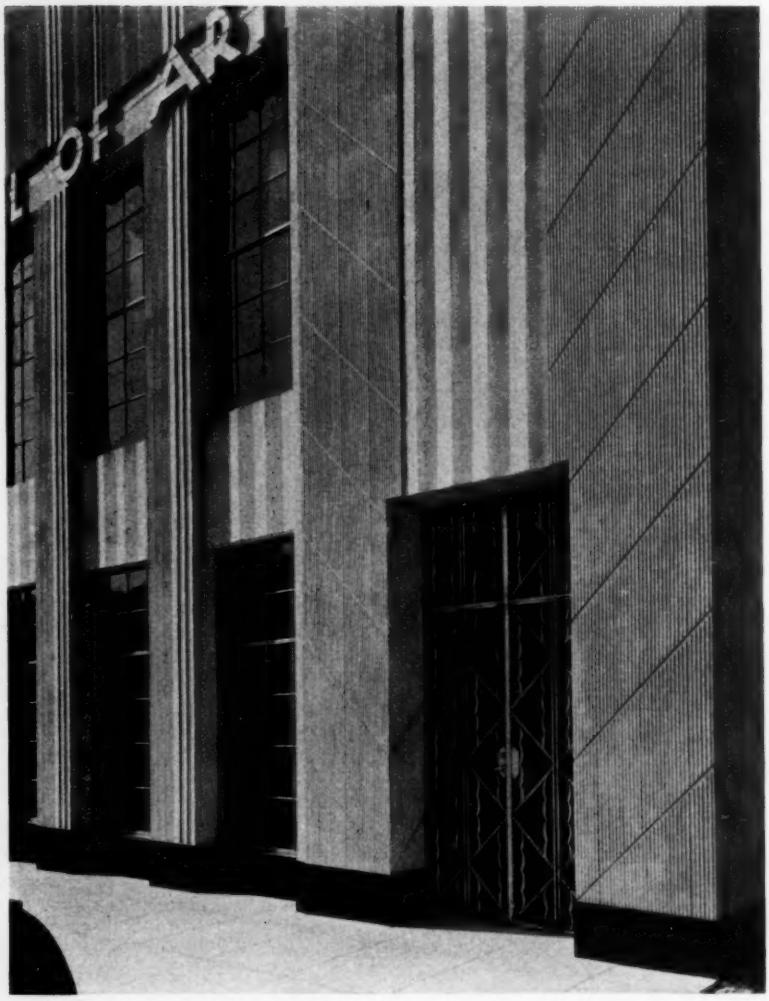

FIG. 13—DETAIL CHOUINARD SCHOOL OF ART

whaler of the new form work is pulled as tight as possible against the top of the concrete previously poured to prevent soiling this surface by leakage of water and cement. Whatever water or laitance leaks through the bottom of the forms must be washed from the lower surface immediately in order to prevent permanent damage.

The removal of forms is an operation that requires extraordinary care to prevent damage to the concrete surface, and it is in this operation that the limitations of design become apparent. Design should provide means of disguising the variations between pours either by actual or painted architectural joints or by applied surface treatments. A mixture of cement and water applied with a brush will conceal slight discolorations and retain the natural color of the concrete.

For ease of stripping there should be no exterior acute angles. To allow for the uneven expansion of forms all exterior angles should be slightly obtuse wherever practicable because of the difficulty of removing the forms without spalling. On wide pilasters where a number of exterior angles occur, a series of kerfs to within ½ in. of the inside face and about 3 in. apart is a very effective method of relieving the possibility of damage to corners by absorbing the expansion of wood molds.

PATCHING AND CURING

To prevent extreme variations in color, it is important that the proportions of the concrete remain constant for similar and contiguous conditions and that the same cement mortar mixture used in the concrete be employed in patching spalls, voids and wire holes. Patching should be done immediately after the surfaces have been inspected and cleaned of all laitance and projecting fins.

Satisfactory curing requires that the concrete be kept wet for at least seven days, but this period varies according to the structural conditions of the concrete. After proper curing the surfaces should be brushed clean of all excess cement that might roll up under a painter's brush or tend to defeat any efforts to apply a finishing material.

Readers are referred to the JOURNAL *for March, 1931, for discussion which may develop. Such discussion should reach the Secretary by February 1, 1931.*

Design and Construction of Bonnet Carre Spillway

*With Special Reference to Concrete**

BY HELMER SWENHOLT†

INTRODUCTION

The bonnet carre spillway now under construction on the left bank of the Mississippi river, about 30 miles above New Orleans, is a controlled spillway 7700 ft. long, emptying in time of unusual flood through a leveed floodway into Lake Pontchartrain, six miles away. Authorized under the Flood Control Act of May 15, 1928, according to the adopted plan it is to be capable of discharging 250,000 sec. ft., leaving 1,250,000 sec. ft. to go by New Orleans, preventing the stage at Carrollton from rising above 20 ft. on the gage. This plan is the outcome of 200 years of discussion and efforts to control the flood waters of the Mississippi river by levees only.

HISTORY

The history of the lower Mississippi River is one of floods. Early settlers along the stream began the protection of their holdings from river encroachment as soon as residence was established. These holdings, in general, were in large grants, and plantations became the center of social and business activity. Small levees were built along their fronts, joining with neighboring levees, or extending rearward towards the swamps for flank protection. A levee along the New Orleans front was completed as early as 1727. Levee building by State and local interests was stimulated by the swamp land act of 1850 following the damage of the floods of 1849 and 1850, and levees were extended and built higher and higher as the South Central States advanced

*Presented at the 26th Annual A. C. I. Convention, February, 1930.
†Captain, Corps of Engrs., U. S. Army.

industrially and agriculturally. Floods kept pace with levee heights, frequently defeating the builders, the river spreading its surplus waters over the adjacent countryside through crevasses and finding its way to the Gulf, or perhaps back to its own channel through bayous, adjoining rivers and lakes. The confinement policy of flood control terminated with the disastrous flood of 1927, and as a direct result of this flood the Flood Control Act of 1928 was passed and the Bonnet Carre Spillway, a subfeature of the adopted plan, was authorized.

This spillway was discussed as early as 1816 and much interesting and instructive data exist in studies made at various times, including the investigation of the Corps of Topographical Engineers in 1850, the Humphreys and Abbott report of 1861, and others. As the result of the flood of 1922, Congress in 1926 authorized a Spillway Board, and its recommendations in House Document No. 95, 70th Congress are the basis for the present design.

DESCRIPTION

The plan adopted by the Flood Control Act of May 15, 1928, provides for the safe discharge of 1,500,000 cu. ft. per sec. below Old River between the main river levees, in detail as follows:

114. At Bonnet Carre a controlled spillway emptying into a leveed floodway to Lake Pontchartrain is to be constructed capable of discharging 250,000 sec. ft. This leaves 1,250,000 sec. ft. to go by New Orleans, and should prevent the stage at Carrollton from rising above 20 on the gauge.

115. The Bonnet Carre spillway is so designed as to afford complete control of the discharge into Lake Pontchartrain. This discharge will be begun when the flood stage at New Orleans has reached 20 on the Carrollton gage; it will be regulated to prevent the stage rising above 20, and will cut off as soon as the stage has fallen below that figure. Past records indicate that its operation will be required about once in five years; and for a period of from one to three months during each flood. The discharge through the spillway, in a maximum flood, will be about 10 per cent of the total flow at that latitude. Some of the silt carried by the discharge will be deposited in the floodway itself, the bulk of it in the upper end of Lake Pontchartrain. With the infrequent and limited periods of operation, the silting would not exceed an average of ¼ in. of depth per annum, even if all the silt content were deposited in the lake within 10 miles of the floodway outlet. The average rate of silting for the entire lake would be $\frac{1}{32}$ in. per annum. Discolored water from the discharge may, in a high flood, extend well into Mississippi Sound, but there will be no appreciable silt content remaining in the water at such a distance. The spillway is especially heavily designed to prevent even the remote possi-

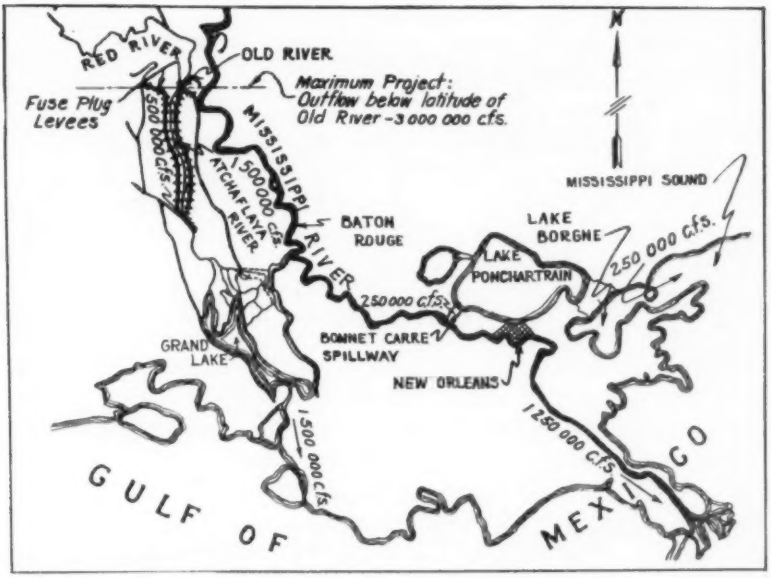

FIG. 1—MAP SHOWING ESTIMATED QUANTITIES OF DISCHARGE THROUGH VARIOUS CHANNELS

bility that the discharge will cut a channel from the river into Lake Pontchartrain.

116. The City of New Orleans has provided, with its own funds, levees on its river front of so wide a crown, and with such flat slopes, as to afford an abundant margin of safety against failure except by overtopping or by bank caving. After the Bonnet Carre Spillway has been constructed, there can be no fear that the flood stages will approach dangerously close to the levee top. The danger of bank caving is minimized by the revetment which has been placed on the under-water bank. The Bonnet Carre spillway will reduce the high current velocities now occurring in great floods. Further insurance can be provided by widening the levees to introduce any desired factor of safety.

In accordance with this plan a site was selected after detailed topographic surveys covering a large area in the vicinity of Bonnet Carre Point, 30 miles above the City of New Orleans. As in other parts of the Alluvial Valley, the river here flows between banks considerably higher than lands back from the river, the banks being about 14 ft. above mean Gulf level, sloping to Gulf level and even lower towards Lake Pontchartrain.

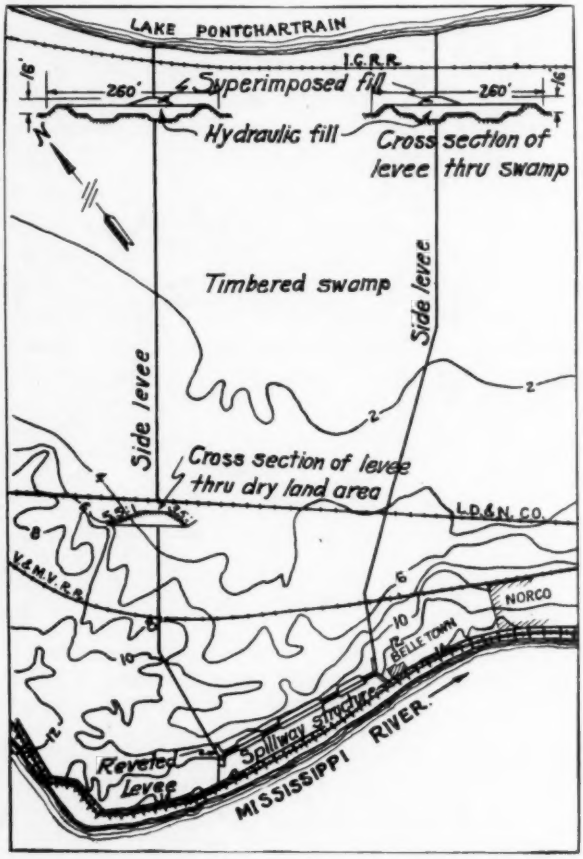

FIG. 2—LOCATION MAP BONNET CARRE SPILLWAY

Of the 7800 acres required, 30 per cent is cultivatable land from 4 to 14 ft. above mean Gulf level, while the remaining 70 per cent bordering on the lake is a low lying timbered swamp, much of the soil consisting of humus and muck. The floodway is crossed by three railroads, one highway, telephone, telegraph and power transmission lines, and a natural gas pipe line. The selected site is shown in Figs. 1 and 2.

DESIGN

In the design of the spillway the following principles governed:

(a) The discharge capacity of the weir must be at least equal to the required discharge under working conditions.

(b) The floodway capacity must be similarly ample.

(c) The structure must be safe, workable and subject to control.

Since the project involved the expenditure of many millions of dollars, it was felt that studies and experiments should be undertaken with great thoroughness. The economic desirability of the project having been previously determined these studies were largely technical, the economic feature entering only into details of design. These technical studies were unusual in that the structure is to rest on an alluvial soil and its operation is to cover all conditions of flow and backwater from no flow to full capacity.

A hydraulic laboratory was established on the site where various scale models were tested for performance. These tests were conducted to determine:

(a) The design which would most effectively dissipate the energy of falling water under any condition of flow.

(b) A design which would withstand such flow and energy as were not dissipated.

(c) A design which would cause the higher velocities of the water leaving the apron to be on the surface instead of at the bottom.

(d) The discharge capacity of weir types.

(e) The velocities at which scouring would occur.

(f) The velocities at which silting would occur.

(g) The rip-rap and toe protection required.

(h) Back water conditions and flow in the floodway.

Foundation tests were conducted also with a view to determining:

(a) The physical characteristics of the soil.

(b) The permeability of the soil.

(c) The bearing capacity of the soil.

(d) The type of foundation most suitable.

These tests and experiments were continued over several months, and influenced features of the design shown in Fig. 3.

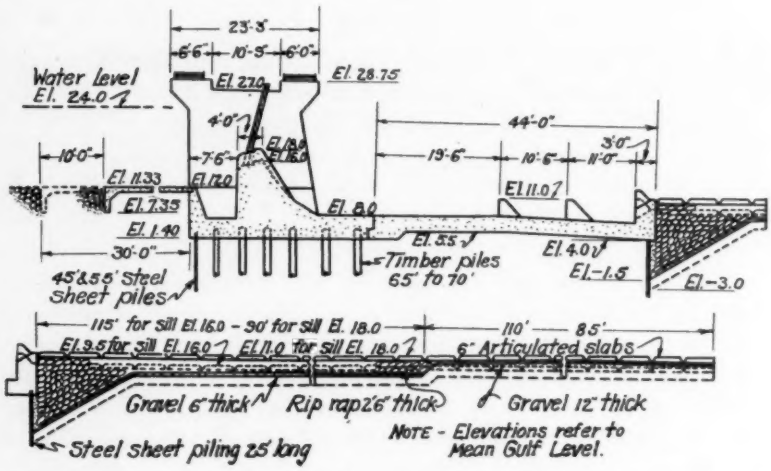

FIG. 3—FINAL DESIGN OF BONNET CARRE SPILLWAY STRUCTURE

The discharge capacity of the structure, which must be at least 250,000 cu. ft. of water per sec., is affected by several factors. It is reduced as backwater in the floodway is built up and the weir becomes submerged; it is increased by the head from a rising river surface above the weir. Computations gave the probable backwater height at the weir; gage relationships between Carrollton at 20 and Bonnet Carre gave a river surface elevation at Bonnet Carre of approximately 24. Discharge capacity was then determined. The concrete structure, 7700 ft. long with 350 20-ft. bays has the required capacity with an ample margin of safety.

FOUNDATIONS

The spillway structure proper rests on untreated wood piles 65 to 70 ft. long. Untreated piles were selected as most economical since their life when cut off below the ground water line is unlimited. The length of these piles conforms to New Orleans practice and the loads are transferred to a safe depth. No point bearing was secured during tests but loads of as much as 90 tons caused no failure of skin friction. The piles are spaced to meet conditions of eccentric loading, the average being 14 tons per

pile, which is standard locally. The fore apron 2.5 ft. thick is separated from the main structure by an expansion joint and rests upon the ground. Experiments indicated that the natural soil should carry this load without undue settlement.

CUT OFF WALLS

A cut off wall of interlocking steel sheet piling 45 to 55 ft. long, driven under the upstream edge of the structure, lengthens the line of percolation. The longer piling was driven to protect a stretch of softer material 1200 ft. along the site. Piling of an arch web section, with a flange and web thickness not less than $\frac{3}{8}$ in., an interlocking strength not less than 7000 lb. per lin. in. of pile, and a section modulus of 3.2 in. cubed was used. It has a copper bearing content of 0.2 per cent. A down-stream curtain wall of similar steel piling 25 ft. long was driven, at the foot of the stilling basin. This wall not only lengthens the percolation line but protects against scour which may occur below the structure. Cut off walls of 25 ft. steel piling are driven between up and down stream piling at intervals of 460 ft.

ABUTMENTS

The abutments at each end of the structure are gravity sections set on piles. A core wall resting on steel sheet piling extends fifty feet into each side levee, and wing walls, making an angle of 15 degrees with the central section, extend 100 ft. each way from these sections. These abutments were built first so that levees behind them would have ample time for settlement before being revetted. This revetment consists of a continuous concrete slab 4 in. thick, wire mesh reinforced, protected with a short cut off wall and rip-rapped.

WEIR

The weir is designed as a gravity section, sufficiently heavy to withstand lateral and uplift pressures. Its face is so shaped as to induce an abrupt drop of water, the eddy under the nappe tending to dissipate more effectively the energy of the falling water. A 4-in air vent through the piers will prevent the formation of a vacuum under this lower nappe. Sill castings to meet the operating needs of the needle type of dam are imbedded in the concrete at the crest of the weir. For maximum efficiency

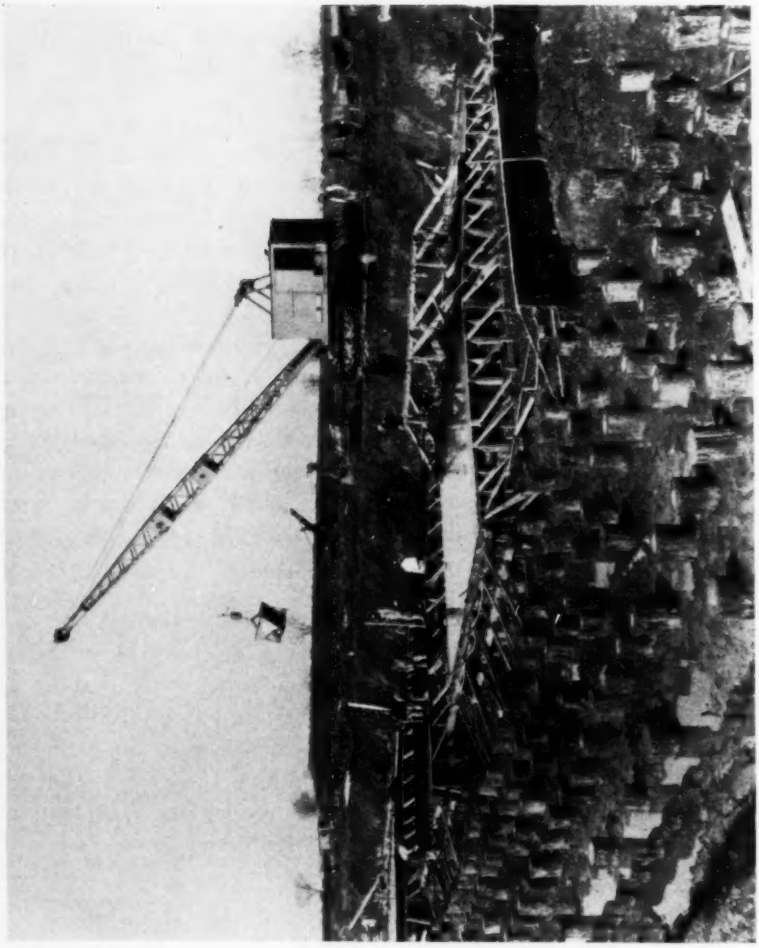

FIG. 4—POURING FORE APRON

and convenience of operation these sills are arranged in alternating groups. Commencing at each abutment, 44 bays have sills at elevation 18, the next 44 consecutive bays having the sills at elevation 16, etc. This arrangement will be seen to provide for a center section consisting of 88 bays having sills 16 ft. above mean Gulf level. Expansion joints ½ in. wide and filled with an approved asphalt filler are provided at the center of every other weir section. These joints extend across the fore apron and stilling basin which lies below the structure proper, and are sealed on the upper side by a 12-in. copper strip extending from the steel sheet piling to the weir crest.

PIERS

The piers are 2 ft. thick, spaced 22 ft. center to center, reinforced with ½ in. bars set vertically. They are designed to withstand safely the pressure of water flowing through an opening on one side only. They are poured in monolith with a half section of weir on each side. The functions of the piers are three fold; they transmit a proportion of the water pressure received through the needles to the foundation; they divide the spillway into compartments whereby flow may be controlled; they carry service bridges from which the spillway is operated and escape bars which support the upper ends of the needles.

NEEDLES

After a study of various types of gates the needle method for control of flow over the spillway was adopted in the interests of economy, simplicity and certainty of operation. The needles are of 8 in. x 12 in. timbers resting on a sill at the weir crest, their tops supported by horizontal escape bars suspended between piers. Spaces between them may be closed by battens to prevent excessive leakage. A full bay may be released simultaneously by tripping the escape bar, but ordinary operation provides for lifting individual needles by means of hand cranes on the service bridges which surmount the piers. These needles when raised will be stored by hooking the lifted ends to one of the service bridges the other ends resting on the escape bar. The service bridges are standard gauge tracks, the stringers of each consisting of two 15 in. 33.9 lb. channels, to form rails for hand cars, the cross bracing forming the beams upon which the decking rests.

FORE APRON AND STILLING BASIN

The fore apron and stilling basin as shown in Fig. 3 consists of a concrete slab, 2.5 ft. in thickness, not reinforced. It is underslung in anticipation of possible settlement and as a better seal against upward pressure, as well as against currents flowing over the weir and apron. It is connected by re-inforcing bars to the main structure. The joint is treated as an expansion joint and has an asphalt filler. The design of this fore apron and stilling basin is regarded as one of the outstanding results of experiments made with the model spillway. The width of apron, location and shape of baffles, height of secondary weir and depth of stilling basin were all worked out in small scale tests which had two objectives: (a) to convert high spillway velocities to mean floodway velocities, and (b) to reduce the bottom velocity of water leaving the stilling basin to 50 per cent of the surface velocities.

A rear apron 9 in. thick, mesh reinforced, and 30 ft. wide lies above the weir. Its purpose is to prevent scour and it serves also to lengthen the percolation line under the dam. There is a shallow cut-off wall on the up-stream edge and a protection of rip rap.

TALUS

The talus of rather unusual design was worked out in model tests. Excavation of varying depth is carried about 200 ft. wide below the baffle wall and on this is laid a 6-in. surface of 3 to 6-in. spalls. Rip rap stone is next placed to a depth of 14 ft. at the wall and 2½ ft., 16 ft. beyond, this latter depth extending to 100 ft., the remaining distance being covered with gravel or spalls only. Over this entire area is poured a flexible concrete mat of considerable extensibility. The mat units are 3 ft. x 3 ft. x 6 in., fastened together, slackly, with copper bearing steel wire which is continued through the slabs as reinforcing. The slabs are beveled on the upper side, better to deflect the water upward, and the whole mat is fastened to the toe wall of the structure by means of reinforcing rods looped through Everdur bars, allowing 2 ft. of settlement at this point. Holes are left in each block for emergency ties.

FLOODWAY AND SIDE LEVEES

The discharge of the spillway will be carried to Lake Pontchartrain through a floodway of 7,800 acres, between levees 7,700 ft. apart at the structure increasing to 12,000 ft. at the lake. The upper levee has a length of 6.27 miles and the lower 5.52 miles. Approximately two miles of each levee back from the river is of the ordinary dry land type of construction; the balance extending to Lake Pontchartrain is being built by hydraulic methods to the section shown in Fig. 2.

As mentioned previously the floodway must be ample to pass the 250,000 sec. ft. discharged over the spillway. A thorough study was made, not only with model tests, but of experiments and records of other channels and floodways. Backwater curves were calculated using the formulas of Chezy and Kutter. Especial weight was given to the Department of Agriculture's determination of the roughness factor in the St. Francis Floodway. A final curve was worked out whereby an economic width is secured, levee heights are not excessive, velocities will not induce scour, and weir submergence will not exceed 60 per cent which is not objectionable. These conditions will be obtained when the floodway is cleared of undergrowth and small trees, leaving stubble and stumps not more than one foot high, and allowing trees of greater diameter than one foot to stand.

The levees are being built with ample freeboard to care for the maximum flow with an added factor of safety to provide for possible floodway deterioration from silting. The levees on the high alluvial land back from the river are of 17 ft. average height, with a crown width 12 ft. and slopes of 5.5 to 1 land side and 3.5 to 1 floodway side. The levees through the swamp section where the top soil is largely of muck and humus require a different construction. A base width of 260 ft. is cleared and two 40-ft. muck ditches dug, the material from which is used to build small confining levees. The space between these levees is then filled hydraulically to a height of about 10 ft. and after this base has dried out there will be built a superimposed levee of standard section to the required grade. About 8,000,000 cu. yd. of material will be placed in these levees. They are under contract and, except for the superimposed sections, it is expected that they will be completed early in 1931.

CONSTRUCTION OF SPILLWAY STRUCTURE

The contract for the spillway structure proper was let in August, 1929, and work started almost immediately. The quantities involved, the unit prices, and the status of the work on June 30, 1930, are shown in the following table:

Items	Estimated Quantities	Unit Price	Total Quantity to Date	Per cent Complete to Date
				June 30, 1930
Common excavation	420,000 cu. yd.	.40	332,296.	79.12
Back fill	8,100 cu. yd.	.37½	2,623.9	32.39
Levee fill	75,000 cu. yd.	.20	61,250	81.67
Steel sheet piling	600,000 sq. ft.	.80	583,104.69	100.00
Steel sheet piling, cut-off	———	———	91.	———
Wood piling	750,000 lin. ft.	.43	746,279.5	100.00
Wood piling, cut-off	———	———	11,076.	———
Class "A" concrete, structural	104,000 cu. yd.	9.50	78,581.4	75.56
Class "B" concrete, revetment	23,000 cu. yd.	10.00	693.	3.01
Rip rap	128,000 tons	———	22,612.95	17.67
Gravel (or spalls) except for concrete	70,000 tons	3.75	21,251.08	30.36
Castings	532,000 lb.	.06½	361,634.97	67.98
Bolts, etc.	75,000 lb.	.08¾	48,047.68	64.06
Reinforcing steel	280,000 lb.	.04½	253,359.19	90.48
Ladder rods	6,200 lb.	.44	3,627	58.50
Structural steel	500,000 lb.	.056	8,018.24	1.60
Reinforcing mesh	122,000 lb.	.07	1,263	1.04
Copper bearing steel reinforcement	537,000 lb.	.047	17,732.55	3.30

This contract awarded to one firm, involves $3,065,957; the service bridges and needles, let separately, will cost an additional $193,933. Completion is required in 530 days after notice to proceed and present progress indicates that the contractor will be well within the limit set.

Excavation, well ahead of pile driving, was done with a 1¼-yd. 50-ft. boom dragline, and the material hauled in dump cars to the side levees over standard gage work track with gasoline locomotives. Excavation was made to grade, but the driving of piles and some inflow of material made much hand work necessary.

Wood piling was driven with two drivers, and steel sheet piling with two smaller drivers and one caterpillar crane with swinging leads, this latter used on the short piling only. Driving was kept not less than 400 ft. in advance of concrete pouring to prevent vibration as well as other interference with that work. With the exception of one short stretch of the steel sheet piling, no particular difficulty was experienced in driving either wood or steel piling and this phase of the contract was finished ahead of schedule, and without interference or delay to the pouring of the weir structure, which began as soon as the abutments had taken a proper set.

CONCRETE

Concrete is the largest single item in the cost of the spillway structure and through sheer bulk and length of distribution is of considerable interest to engineers. One hundred thirty-three thousand cu. yd. is being poured over a stretch of 7,700 ft. and many problems have arisen in its proportioning and handling. Class "A", structural, 110,000 cu. yd., includes the weir and pier structure, aprons, abutment and core walls, and must have a water-cement ratio of .87 (6½ gal. of water per sack of cement) and a minimum compressive strength of 2,250 lb. per sq. in. at 28 days. Class "B," revetment, 23,000 cu. yd., is used in the flexible slab talus and the revetment for side levees, and must have a water-cement ratio of 1.07 (7½ gal. of water per sack of cement) and a minimum compressive strength of 1500 lb. per sq. in. at the same age. Durability and impermeability are the objects of the design; the high strength required is necessarily developed in the mixtures specified.

TESTING AND INSPECTION

A laboratory was established at the spillway site before construction was started, and complete preliminary investigations were made to determine the mix to be used. Studies were made of the fitness of available materials, the cement factor, the most desirable quality of concrete and the approximate cost.

Concrete aggregates, secured from three pits on the Tangipahoa river in Southeastern Louisiana were clean and hard, with negative colorimetric tests, containing about 0.2 per cent clay and silt, and having the following sieve analyses:

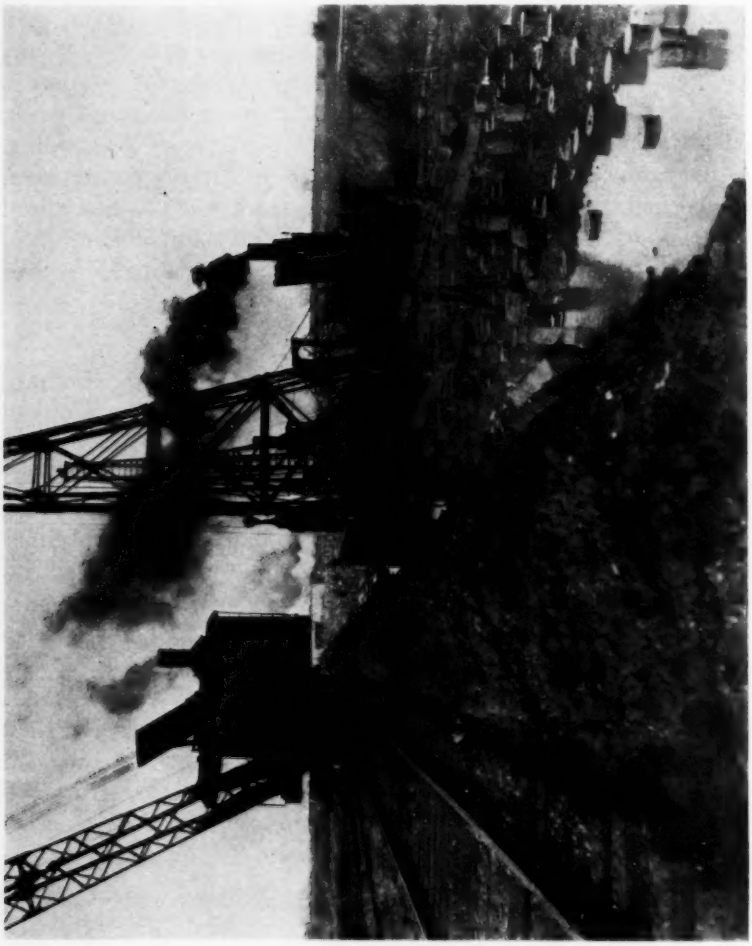

FIG. 5—DRIVING STEEL SHEET PILING — UPPER CURTAIN

GRAVEL

Size	Pit No. 1	Pit No. 2	Pit No. 3
1½ in.	0	0	0
¾ in.	28.2	26.6	25.9
⅜ in.	58.5	58.7	61.2
No. 4 sieve	6.7	8.1	8.0
No. 8 sieve	6.6	6.6	4.9
F. M.	7.08	7.05	7.07
Unit wt. lb.	101.	101.	100.
Spec. Gravity	2.64	2.65	2.64

SAND

Sieve No.	Pit No. 1	Pit No. 2	Pit No. 3
4	.4	.4	1.7
8	9.3	16.5	9.6
14	8.7	14.6	7.3
28	18.8	21.6	18.5
48	45.1	34.2	50.1
100	17.7	12.7	12.8
F. M.	2.48	2.89	2.56
Unit Wt. lb.	110.	113.	108.
Spec. Gravity	2.63	2.66	2.62

These tables would indicate that the aggregates were similar in gradation, but variation in shipment from any of the three pits is greater than the average difference between them. It was felt, therefore, that daily sieve analyses would be necessary to keep the mix workable and the concrete uniform, and to avoid too great fluctuation of the cement factor. The cement used comes from Alabama in bulk, is almost wholly free from lumps, and is shown by 7- and 28-day briquette tests to have a strength 25 per cent in excess of the A. S. T. M. standards. Ordinary Mississippi river water is used, and while it has a high silt content, no objectionable results have been obtained; in fact some of the high strength obtained in tests may be due to this presence of silt in the water. Preliminary investigations showed that materials were excellent, though poorly graded, and that good concrete could be made from them. As anticipated, however, actual field conditions and differences in the aggregate have made necessary constant revision in the mix as designed. The cement

factor has varied from 5.65 to 5.91 sacks of cement per cu. yd. of concrete, but the cost of raw materials has at no time exceeded $4.28 per yard.

The concrete inspection and field testing laboratory is under one head, thus unifying what are often two distinct departments, and making possible an immediate and constant check on all phases of the work and close co-ordination of action. An outside laboratory makes mill tests of all cement purchased, furnishing copies of results to the field laboratory. Cars are sampled and tested as received, and bin tests are made to prevent use of damaged or deteriorated cement. Aggregates are tested as received and before unloading, and samples sent to the laboratory for checking and recording. At least twice daily, cylinders are made from the concrete at the mixer and again after it has been placed in the forms. The mixer samples are given laboratory curing, those from the forms are cured under field conditions; careful records of both types are kept and parallel graphs of compressive strength at 7 days, 28 days, 3 months and 6 months, are plotted. Weight is given to precipitation, laboratory and ambient temperatures and relative humidity, and a composite chart of local weather conditions is plotted from observations taken three times daily.

MIXING

A mixing plant, central with reference to the longitudinal axis of the weir serves the purpose of the work. Here are installed two 1-yd. mixers equipped with inundators. Cement is lifted to the storage bins by compressed air and fed to the hoppers through a weighing device which closely checks the actual cement consumption and offers a practical gage for the theoretical cement factor. A 3-in. slump is desirable from the standpoint of workability, but is maintained with difficulty, due apparently to variation in the size of aggregates. It is necessary also to keep a constant check on the moisture content of the aggregate, particularly after a rain, and compensate for extra moisture with additional cement to maintain the proper ratio. Mixing is continued at least 1½ min., with 12 revolutions of the drum traveling at a rate of 200 ft. per min. The finished concrete is then dropped into buckets, which are conveyed by truck to the forms for pouring.

Transportation during the winter months and prior to construction of the fore apron, was hindered by soft roads, necessitating the use of mats. This difficulty was overcome, however, and for several months it has been possible to operate at the full capacity of 56 yd. per hr., a fleet of 4½ ton trucks, each carrying two 1-yd. buckets, hauling the concrete to the site of the work where it is lifted and poured by a caterpillar crane.

CHARACTER AND ORDER OF CONCRETE CONSTRUCTION

The specifications for concrete work require puddling along the face of all forms, the surface to be free from voids, and no plastering permitted. Defective concrete must be removed and new concrete keyed, dovetailed or anchored in its place. All top surfaces have a float finish without mortar, and all angles are rounded or beveled unless definitely specified otherwise. A curing period of 12 days is required for all horizontal surfaces, and 10 days for vertical surfaces. Water curing is used though wide latitude is allowed.

The two abutments were constructed first to give ample time for placement and settlement of adjoining levee before revetting with concrete. Forms of surfaced lumber, sealed with paraffin oil, were used; the sub-foundation was roughly surfaced and spread with a coating of sand, and the wood and steel sheet piling were scrubbed clean. Particular care was used in the puddling and placing of concrete, the result being walls entirely free from honeycombing. Some difficulty was experienced on the first abutment in holding the forms true to line, caused by the high lifts attempted, 13 to 15 ft. This height was reduced by half on the second abutment and no such trouble occurred.

Construction of the fore apron and baffle seats was started as soon as the abutments were finished. Beginning at the west end, alternate sections 22 ft. long, were poured. The two side bulkheads and rear face forms were of wood and the forestepped bulkhead was of steel. Side bulkheads were omitted when the intermediate slabs were poured. Perfect alignment of the baffle seat insets proved difficult until a special bridge was constructed and the sections lined separately with a transit.

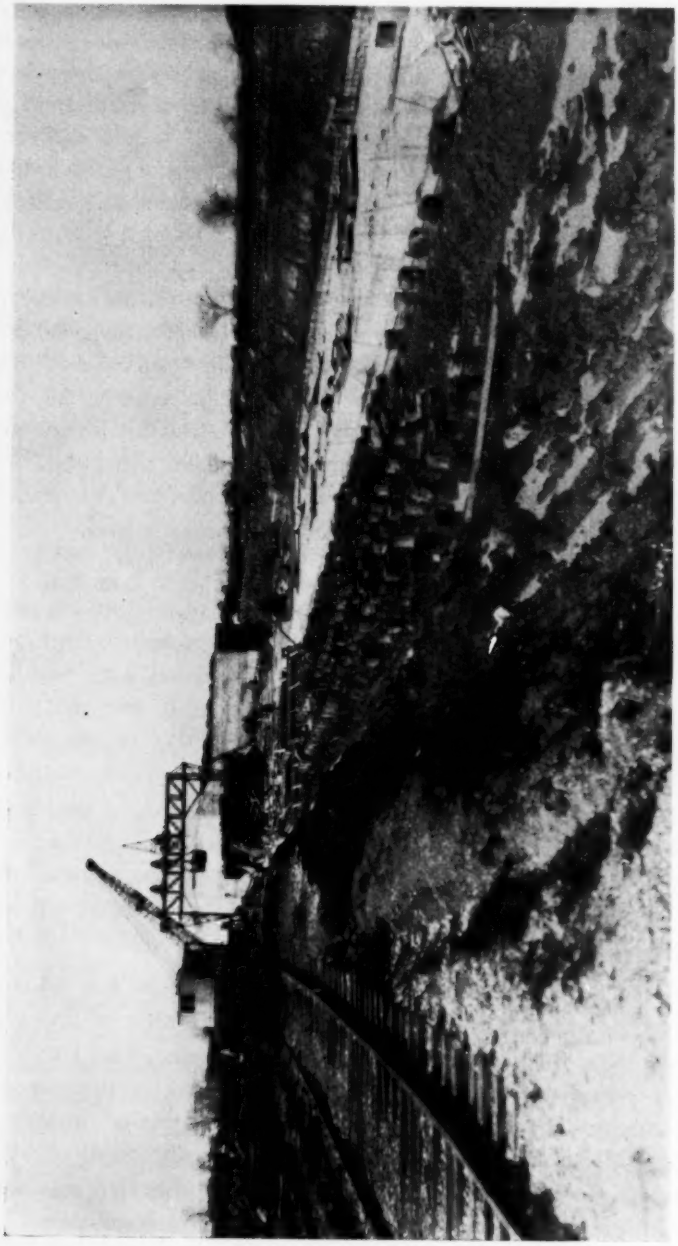

FIG. 6—PLACING FORMS FOR WEIR SECTION

FIG. 7—CUT-OFF DITCHES—SWAMP SECTION LEVEE BASE

Pouring of the weir and pier base was started in December, 1929. This is a heavy slab, 4 ft. deep, built in 22 ft. sections with expansion joints at 44 ft. intervals. Upon this base rests the pier weir section started in January, 1930. Steel forms are used. They are fitted together to form a mold for a pier and half section of weir on each side. Pouring is continuous to the weir crest where a construction joint is prepared and the upper part is continuous to the weir crest where a construction joint is prepared and the upper part of the pier poured separately.

CONTRACTS

The contract for the entire spillway structure except for service bridges and needles is being undertaken by Stevens Brothers, St. Paul, Minn., and The Miller Hutchinson Co., Ocean Springs, Miss., combined. Doullut and Ewin, Inc., New Orleans, who will erect the service bridges and needles, also drove all piling under sub-contract. The dry land levees are being built by Boone and Wester, Sellers, La., the lower hydraulic section by the McWilliams Dredging Co., New Orleans, and the upper hydraulic section by Jahncke Service, Inc., New Orleans.

CONVENTION DISCUSSION

B. Moreell (Washington, D. C.): I would like to ask Captain Swenholt about the reinforcement for the flexible mat. I understood that copper bearing steel wire was to be used. Is that right, or is it copper covered?

Captain Swenholt: Copper bearing steel wire was decided on. There was a great deal of difference in the first cost. The copper bearing steel was believed amply good, and in case of deterioration, we could fasten the slabs together again, so rather than go to that additional expense, we selected the copper bearing wire. As a matter of fact, the real reason was the difference in first cost.

B. Moreell: How was the bearing power of the wood piles determined? Were they driven by formula?

Captain Swenholt: The bearing power of the wood piles was determined as the result of several things. In the first place, we conducted tests at the spillway to get the bearing power. We then employed J. F. Coleman, New Orleans, as a consulting engineer, and he, in conjunction with others, studied the results of these tests. The recommendation of Mr. Coleman was fourteen tons for each pile, and that was adopted.

B. Moreell: I think you do not understand my question. I want to know if you pre-determined the length of the pile and then drove that length, or determined the bearing power of the pile as you drove it, from the *Engineering News* formula?

Captain Swenholt: We tested the piles after they were driven. We computed the bearing capacity of piles from the *Engineering News* formula, but it did not seem to check with the actual results we got on our tests at the structure.

B. Moreell: In other words, you made a load test and then determined the number of piles required from your load test?

Captain Swenholt: Yes, sir.

Readers are referred to the JOURNAL *for March 1931, for discussion which may develop. Such discussion should reach the Secretary by February, 1, 1931.*

Composite Columns

BY L. J. MENSCH*

The composite column here considered is of hooped concrete with standard spiral and vertical reinforcement and with an additional heavy strengthening member or members of cast iron or steel inside the hooping. The spiral reinforcing is generally 1 to 1½ per cent, the vertical steel bars 1 to 4 per cent and the heavy metal core from 2 to 50 per cent of the area inside the hooping. Standard hooped concrete columns are considerably larger than fireproofed steel columns for loads greater than about 200,000 lb.

In high buildings, loads from one to two million pounds are common, requiring concrete columns from 3 ft. 0 in. to 4 ft. 6 in. square. No wonder architects and owners decide to use steel skeletons, although their cost is at least 6¢ per cubic foot higher than for concrete. In some instances engineers have used steel columns, or even steel skeletons for the lower part of a high building and reinforced concrete for the upper part, but results were not quite satisfactory, in having two different contractors working on the frame, which delayed progress and wasted money. As will be shown, composite columns can be designed to fail at a unit stress of 30,000 lb. per sq. in. of the spiral area, which is a considerably greater load than a fireproofed steel column can carry.

Composite columns were first investigated by the well known concrete pioneer Dr. F. Emperger, remembered in this country as the builder of the first Melan type of arch bridge, 36 years ago. He first tested structural steel columns embedded in plain concrete and found the strength of the combination to be considerably less than the sum of the strengths of the structural steel and

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of the concrete. Cast iron columns embedded in plain concrete gave still more unsatisfactory results. He found that the plain concrete failed first and that the shock of the failure of the concrete made the cast iron fail at a lower load than when tested alone.

The combination of cast iron core with hooped concrete was the next step and Dr. Emperger obtained results which showed that the strength of this combination is greater than the sum of the strength of hooped concrete alone and of the cast iron alone.

The difference in behaviour of plain and hooped concrete columns may be explained by the different compressibility of plain and hooped concrete. Plain concrete fails at a shortening of 0.001 of its length, while hooped concrete fails at a unit deformation of 0.01. At a unit deformation of 0.001, steel is stressed to about 30,000 lb. per sq. in., and cast iron to about 15,000 lb.; At a unit deformation of 0.01, steel is stressed to about 35,000 lb. per sq. in. and cast iron to from 50,000 to 100,000 lb. per sq. in., depending on the grade and provided that the strength is not reduced by deflection, or increased by lateral restraint. Hooped concrete forms such a lateral restraint and the object of all tests made up to this time, has been to find the law governing it. To recognize this restraint we have to know the strength of the metal core without its shell of hooped concrete.

We are still in the dark about the strength of structural steel, as the final report of the special committee of the A. S. C. E. on steel columns and struts clearly showed, and we are still less informed about the strength of cast iron members. For structural steel of heavy sections, and only those are of interest in composite columns, we can assume the ultimate strength for l/r = 50, 85, and 150 as 35,000, 32,000 and 23,000 lb. per sq. in., respectively. For cast iron without any defects a formula similar to Tetmayer's formula seems to give the nearest results. The ultimate strength per sq. in. = $100{,}000 - 1500\ l/r + 7\ (l/r)^2$.

This formula gives the following values:

l/r	20	30	40	50	60	70	80
Ultimate strength, lb. per sq. in.	72,800	61,300	51,200	42,500	35,200	29,300	22,800

The tests made by Dr. Emperger were under the auspices of the Austrian Committee for Reinforced Concrete and are described in No. 3 and No. 11 (1912 and 1927) of the publications

of that Committee and in No. 11 of the Oester. Wochenschrift fur den Offentlichen Baudienst of 1915.[1] The most important results are summarized in Table 1, while Table 3 shows all the particulars of the highly interesting group of 1926. These latter tests were comprehensive and included six standard hooped concrete columns, with 12 in. spiral of 0.64 to 1.65 per cent, with 1.1 per cent of vertical bars, and of a concrete mixture which varied from 1:8 to 1:4½.

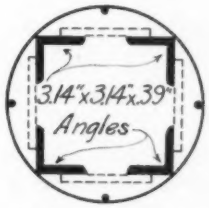

FIG. 1—SECTION OF COMPOSITE COLUMN WITH FOUR VERTICAL STEEL BARS AND FOUR CAST IRON ANGLES. SEE TABLE 3

These columns were tested at ages from 14 to 69 days and gave ultimate strengths of the hooped concrete from 1942 to 5420 lb. per sq. in. Then 14 composite columns were made, having the same dimensions and properties as some of the standard hooped concrete columns, but reinforced in addition by 4 cast iron angles 3.14 x 3.14 in. x .39 in., tied together every 10 in. as shown in Fig. 1. They were tested at the same age as the corresponding standard columns. The difference in strength was ascribed to the cast iron core, and the stresses varied from 60,000 to more than 100,000 lb. per sq. in.

Concrete 14 days old seemed to show as good a stiffening effect as concrete 69 days old and the only positive conclusion we can draw from these tests is that 1 per cent and 1½ per cent spiral reinforcement gave more uniform and slightly higher stiffening effect than smaller spirals. It is true, however, that the l/r of the cast iron core was already very small, namely,

[1]See also Proceedings, American Society of Civil Engineers, 1923, V. 26, p. 1185.

TABLE I—EUROPEAN TESTS

Ratio of Length to Diameter of Spiral	2	4.5	4.9	5.3	6.75	6.8	8	8.7	8.75	9	11.5
Diameter of Column (Inches)	15.25	8	12	16	8	15.25	14	15.25	9.6	8	10.3
Number of Columns Tested	1	1	2	8	1	1	12	1	2	2	3
l/r of Metal Core	16	44	17.5	15	66	57	26.5	72	73	88	79
Per Cent of Metal Core	6	6	9	12	6	6	9	6	7	6	7
Ultimate Stress on Cast Iron, Lb. per Sq. In.	100,000	100,000	100,000	70,000	87,000	77,000	60,000 to 100,000	70,000	77,000	50,000	50,000
Ultimate Stress on Mild Steel, Lb. per Sq. In.			47,300								

TABLE II—AMERICAN TESTS

Ratio of Length to Diameter of Spiral	6	8	9.25	9.25	10	10.3	12	12.9	14
Diameter of Column (Inches)	12	12	6.5	6.5	12	7	12	6.5	14
Number of Columns Tested	2	4	6	2	6	4	2	4	2
l/r of Metal Core	50	66	60	48	83	144	99	84	116
Per Cent of Metal Core	11	11	38	59	11	8	11	38	11
Ultimate Stress on Cast Iron, Lb. per Sq. In.	51,400	42,700	38,500	44,900	41,600	53,500	42,400	33,300	36,500
Ultimate Stress on Mild Steel, Lb. per Sq. In.			36,800			56,300		34,400	

26.5, and the percentage of metal was only 9. Very interesting is the comparison between Columns II and IIIm, which were only 59 in. high. Column II had four structural steel angles and column IIIm four cast iron angles of the same size. Their l/r was only 17.5 and the cores ought to have been stressed nearly to their ultimate strength. Indeed it was found that the structural steel angles contributed 47,300 lb. per sq. in., and the cast iron angles 100,000 lb. per sq. in. to the ultimate load of the composite columns.

In order to verify Dr. Emperger's tests under American conditions the writer had 18 composite columns made, 12 in. in dia. and from 6 ft. to 14 ft. long, with 0.6 per cent each of spiral and vertical reinforcement and with a center cast iron core of pipe 6 in. in dia. and ¾ in. thick. These columns were tested by the U. S. Bureau of Standards in 1916 and a full description of the tests may be found in the 1917 Proceedings of the American Concrete Institute.[2] A summary is shown in Table 2. The stresses on the metal core were found considerably smaller than Dr. Emperger's tests and were ascribed to the poor quality of the hollow cast iron cores which showed great unevenness in thickness.

In 1918 the writer had a new set of tests made of composite columns at the Armour Institute of Technology. These columns consisted of: two standard hooped concrete columns 7 in. in dia. and 6 ft. long with 1 per cent each of spiral and vertical reinforcement; two columns, as above, with a solid shaft of cast iron 2 in. in dia. in the center; two columns as above with a solid shaft of mild steel 2 in. in dia. in the center; two cast iron bars 2 in. in dia. and 6 ft. long; and two mild steel bars 2 in. in dia. and 6 ft. long.

The hooped concrete columns failed at 5010 lb. per sq. in., the cast iron bars tested alone failed at 18,775 lb. per sq. in., the steel bars at 20,375 lb. per sq. in., while the metal cores in the composite columns contributed 53,500 and 56,300 lb. per sq. in., showing a very large stiffening effect, which must be ascribed to the comparatively small percentage of metal reinforcing.

[2]A. C. I. *Proceedings*, Vol. 13, p. 22.

TABLE III—TESTS ON EMPERGER COLUMNS—1926—MADE BY THE AUSTRIAN CONCRETE COMMITTEE

Mark	Length In.	Dia. of Spiral In.	Ratio Length to Dia. l/d	Area of Core Sq. In.	Vertical Reinforcement 4 Bars .63 In. Ø Area Sq. In.	Vertical Reinforcement 4 Bars .63 In. Ø Per Cent	Area of Structural Steel Sq. In.	Area of Structural Steel Per Cent	Area of Cast Iron Sq. In.	Area of Cast Iron Per Cent	Spiral Reinforcement Size of Wire In.	Spiral Reinforcement Pitch In.	Spiral Reinforcement Per Cent	Mix Cement to Sand Plus Stone	Age. Days	Cylinder Strength Lb. Per Sq. In.	Ultimate Load on Column Total Lb.	Ultimate Load on Column Lb. Per Sq. In.	Load Considered Carried by Hooped Concrete and Vertical Steel Bars Values of Lb. Per Sq. In. Derived From	Load Considered Carried by Hooped Concrete and Vertical Steel Bars Total Lb.	The Remainder of the Load Carried by Structural Steel or Cast Iron Total Lb.	The Remainder of the Load Carried by Structural Steel or Cast Iron Lb. Per Sq. In.
Hooped Concrete Columns with 4 Vertical Bars and Cast Iron Cores																						
IIIa	59.5	12	4.96	113.5	None		9.93	8.75	197	2.24	.57	1:6½	24			971,000	8,550	2,300	I_c	238,000	733,000	73,900
" b	"	"	"	"	1.245	1.10	"	"	"	2.085	.60	"	"			1,032,000	9,100	2,640	"	274,000	758,000	76,600
" c	"	11.85	5.07	110.0	"	1.13	"	"	"	1.97	1.00	"	"			1,138,000	10,000	3,174	"	329,000	808,000	80,200
" d	"	11.63	5.07	106.0	None	1.18	"	"	275	2.166	.93	1:6½	24			1,010,000	8,900	1,600	I_a	166,000	844,000	85,000
" e	"	11.63	5.07	106.0	"	1.18	"	"	197	2.085	.60	"	14			1,085,000	9,560	2,650	I_c	274,000	811,000	81,700
" f	"	"	"	"	1.245	1.10	"	"	"	2.05	.61	"	24			1,145,000	10,080	3,080	I_c & d	318,000	827,000	83,300
" g	90.5	11.24	8.06	99	None		10.25	10.35	197	2.01	.67	1:4½	"			1,067,000	10,770	3,000	"	266,000	801,000	78,200
" i	"	11.03	8.20	95.5	"		4.78	5.00	"	2.32	.59	1:6½	24			640,000	6,700	2,220	I_c	201,000	439,000	91,800
" k	"	"	"	"	1.245	1.305	"	"	"	2.20	.62	"	"			707,000	7,400	2,564	"	233,000	474,000	99,100
" m	59	11.63	5.07	106.0	"	1.18	9.93	9.37	275	1.97	1.02	"	14			1,213,000	11,450	2,200	I_a	211,000	993,000	100,000
" p	90.5	12	7.54	113.5	"	1.10	"	8.75	"	1.18	1.65	1:8	39			1,242,000	10,950	3,575	I_f	370,000	872,000	87,900
" q	"	"	"	"	"	"	"	"	"	1.26	1.54	1:4½	57			1,544,000	13,600	5,000	I_e	518,000	1,026,000	103,500
" r	"	11.85	7.64	110.0	"	1.13	"	10.3	"	2.24	.88	1:6½	24			944,000	8,580	3,015	I_c	302,000	642,000	64,700
" s	"	11.24	8.06	99	"	1.25	"	10.0	197	2.05	.66	"	21			960,000	9,700	2,700	"	241,000	719,000	72,500
" t	"	12	7.54	113.5	"	1.10	"	8.75	"	1.70	.76	1:4½	57			1,169,000	10,300	5,500	I_b	570,000	599,000	60,400
Hooped Concrete Columns with 4 Vertical Bars and Structural Steel Core																						
II	59					1.10	9.37	8.25	275	1.181	1.65	1:8	39	2,160		816,000	7,190	3,575	I_f	373,000	443,000	47,300
Standard Hooped Concrete Columns with 4 Vertical Steel Bars																						
Ia	59.5	12	4.96	113.5	1.245	1.10					.197	1.97	.64	1:6½	14	1,336	220,500	1,942				
" b	59	11.85	5.07	110.0	"	1.13					"	"	.65	1:4½	57	3,940	596,000	5,420				
" c	59	11.63	5.07	106.0	"	1.18					275	2.166	.93	1:6½	24	1,479	326,500	3,080				
" d	59	11.63	5.07	106.0	"	1.18					"	1.30	1.55	"	30	1,792	392,500	3,700				
" e	59.5	12	4.96	113.5	"	1.10					"	1.26	1.54	1:4½	57	3,940	507,700	4,470				
" f	59	12	4.92	113.5	"	1.10					"	1.181	1.65	1:8	39	2,160	406,000	3,575				

4 I.S. 3.14 in. x 3.14 in. x .39 in. tied 10 in. c. c.

To enable the engineers of the new building Code Committee of the City of Chicago to make a comprehensive ruling on composite columns, and especially to find the carrying capacity of metal cores having a large section in comparison with the hooped concrete area, the writer had a new set of columns made on July 13, 1930. These were tested by Prof. W. J. Putnam in the Laboratory of the University of Illinois, in the presence of members of the staff of the University and the Chicago committee. Fourteen columns were tested, having an outside diameter of spiral of 6½ in., the spiral being made of No. 12 high carbon wire at ½ in. pitch. The vertical reinforcement consisted of four ½-in. high carbon bars. The spiral amounted to 1.075 per cent and the vertical bars to 2.35 per cent of the core area. In addition, six columns had 4-in. cast iron cores, representing 38 per cent of the spiral area; two columns had 5-in. cast iron cores, representing 59 per cent of the spiral area; and four columns had 4-in. mild steel cores, representing 38 per cent of the spiral area.

The columns were 5 ft. and 7 ft. long, and two of the cast iron cores were spliced in the center of the height by means of thin wrought iron pipes 5 in. in dia. and 10 in. long. The concreting of the columns was done by foundry workers and the workmanship was not better than that found on the average job. The metal cores were squared at the ends, but were not placed quite square or quite plumb in the forms and it was the intention to have the column ends squared after the concrete was 2 weeks old. This was found impracticable with the tools at hand and the columns were tested with ends in which the concrete was not always even with the metal cores. The thickness of the concrete between metal core and the spiral was only ¾ in. to 1¼ in., which made tamping difficult and voids in the concrete could not be altogether eliminated. Therefore in estimating the load considered to be carried by the metal core, the load carried by the hooped concrete was taken as 5000 instead of the 5750 lb. per sq. in., which was the average strength of the two standard hooped concrete columns tested.

The tests of the spliced cores gave higher results than those of unspliced cores, hence we can say that splices as used do not diminish the strength of composite columns. The same result

was found with spliced cores in some of Emperger's tests and in those of the U. S. Bureau of Standards. None of the cast iron cores failed by breaking. The columns failed by deflection and at the ultimate load some spiral wires were broken. Again the ultimate stresses on the cast iron cores were lower than in the European tests and it is now clear that the hard grade of cast iron used there is more suitable than the soft machinery cast iron obtainable here. The results of the tests are given in Table 4 and are summarized in Table 2. All the tests mentioned show a considerable range of results and it is very difficult to formulate a rule which fits all conditions. It can be positively stated, however, that Dr. Emperger's claim of the strength of the composite columns being greater than the sum of its components has been verified by every test. It can also be affirmed that for columns of $l/d < 6$ and percentages of metal cores < 12 per cent, the stresses on cast iron cores are always greater than 50,000 lb. per sq. in. on common grade of cast iron, and greater than 40,000 lb. per sq. in. on structural steel. For columns having an $l/d = 8$ to 12 and metal cores less than 12 per cent, the ultimate stresses on cast iron equals 40,000 to 53,000 lb. on common grade, and 50,000 to 100,000 lb. per sq. in. on hard grade material. For columns having an $l/d = 14$, the ultimate stresses on the cast iron cores were found to be 36,600 lb. per sq. in. The tests further clearly show that the l/r of the metal core has a large but not preponderant influence on the result. Where l/r was smaller than 30 we always find stresses near the cubical strength of the material, and for l/r smaller than 50 the ultimate stresses on the cores are still very high. On the other hand for percentages of the metal core smaller than 9 (not very important in composite columns) the concrete exerted such a large stiffening effect, especially where l/d was smaller than 9, that the stresses in the metal cores were still found very high for very large values of l/r. The stiffening effect of the concrete is still clearly seen in composite columns with 38 per cent of metal core. While Tetmayer's formula would lead us to expect an ultimate strength of the cast iron of 35,200 lb. per sq. in. for a l/r of 60, the tests showed 38,500 lbs., and for an l/r of 48 we obtained 44,900 lb. per sq. in. against 44,200 according to Tetmayer.

The 4-in. mild steel cores showed stresses of 36,800 and 34,400 lb. per sq. in. as compared with 34,500 and 32,000 lb. per sq. in. by the formula. In nearly all cases common grade of cast iron proved more efficient than structural steel. Where stresses in the cores were less than 50,000 lb. per sq. in., the first cracks always occurred at 70 to 80 per cent of the ultimate loads. At the U. S. Bureau of Standards laboratory, elaborate extensometer tests were made and it was found that the vertical steel bars were stressed to the elastic limit long before the ultimate load was reached, and that the unit deformation of steel and concrete at ¼ load was 0.00035.

The present rulings on composite columns were not based on the tests above mentioned. The Chicago ruling under which quite a number of large buildings have been constructed with composite columns allow the following design stresses:

Stress on hooped concrete of 1:1:2 mix with 1 per cent of spiral	800 lb. per sq. in.
Stress on vertical bars	14,000 lb. per sq. in.
Stress on cast iron cores	10,000 lb. per sq. in.
Detroit Ruling:	
Stress on hooped concrete, 1:1:2 mix, with 1 per cent each of spiral and vertical reinforcing	1,120 lb. per sq. in.
Stress on cast iron cores	11,200 lb. per sq. in.
Joint Committee:	
Stress on 1:1:2 concrete with one per cent spiral	1,250 lb. per sq. in.
Stress on vertical bars	7,500 lb. per sq. in.
Stress on steel cores not to exceed	15,000 lb. per sq. in.
Stress on cast iron cores not to exceed	9,000 lb. per sq. in.
The cast iron cores are limited to 12 per cent.	

From the tests made at the Armour Institute and at the University of Illinois it is clear that the Joint Committee ruling favors structural steel and underestimates the value of cast iron, and on the other hand allows too low stresses on the vertical bars. The limitation of the cast iron cores to 12 per cent is wrong. The writer would propose stresses on the concrete as per ruling of the Joint Committee, stresses of 10,000 lb. per sq. in. on vertical bars, stresses on the metal cores, depending on the ratio of length to diameter as follows:

For l/d —	6	8	10	12	14	16
Permissible unit stress on metal core	13,000	12,000	11,000	10,000	9,000	8,000

TABLE IV

TESTS OF COMPOSITE COLUMNS MADE AT THE UNIVERSITY OF ILLINOIS, JULY 23, 1930, IN BEHALF OF L. J. MENSCH

Number of Column	Fig.	Length of Column, Ft.	Ratio of Length to Diameter	Size of Solid Round Metal Core In.		Area of Spiraled Core, Sq. In.	Area of Metal Core, Sq. In. Percentage	Actual Concrete Area, Sq. In.	Load Considered Carried By		Load Carried by Concrete and Four ½-in. ∅, 1000 Lb.	Actual Test Load in 1000 Lb.		Load Carried by Metal Core		Average Load Carried per Sq. In. of Spiraled Core-Area, Lb.	Load at First Crack, 1000 Lb.
				Cast Iron	Mild Steel				Concrete at 5000 Lb. per Sq. In., 1000 Lb.	Four ½-in. ∅ at 4000 Lb. per Sq. In., 1000 Lb.			Average	Total 1000 Lb. Average	Lb. per Sq. In.		
1	2	5	9.25			33.2	No	M	etal	Co	re	255				7,680	
2		7	12.9									193				5,810	
3	3	5	9.25	4		33.2	12.6	19.8	94	32	12.6	606	611	485	38,500	18,400	485
4							38					616					470
5	3	7	12.9	4		33.2	12.6	19.8	94	32	12.6	525	545	419	33,300	16,400	490
6							38					565					
7	3	5	9.25	4		33.2	12.6	19.8	94	32	12.6	646	636	510	40,500	19,150	
8							38 Spliced		Cen	ter		626					
9	4	5	9.25	5		33.2	19.6	12.8	64	32	.96	980	988	892	44,900	29,800	
10							59					997					740
11	3	5	9.25		4	33.2	12.6	19.8	94	32	12.6	591	589	463	36,800	17,750	550
12							38					588					
13	3	7	12.9		4	33.2	12.6	19.8	94	32	12.6	557	559	433	34,400	16,850	530
14							38					561					525

All spirals consisted of No. 12 with ½ in. pitch. Area of spiral core, 33.2. Equiv. area of spiral, 1.075 per cent of spiral core. Area of four ½-in. ∅ = .784 sq. in. = 2.35 per cent of spiral core.

Concrete mixture 1:1:2. Columns were 40 days old when tested.

FIG. 2

FIG. 3

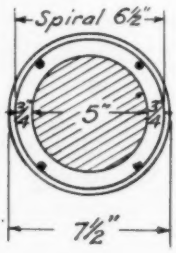

FIG. 4

which would result in factors of safety of 3.5 to 5 depending on the percentage of metal reinforcement used and on the l/r of the core. Composite columns have shown great uniformity of results where duplicate tests have been made, and they are just as reliable as steel columns. Hence the proposed factor of safety is very conservative in comparison with that of steel columns which is generally only 2½ and sometimes less.

As a result of these tests there are these observations:

High carbon wire for spirals was found much superior to ordinary steel wire, and the increase in strength of the hooped concrete was found proportional to the elastic limit of the hooping wire, or the ultimate strength in case of hard wire. A close pitch of the spiral wire produced more uniform results than a large spacing, and is very important in composite columns because the thickness of the concrete between core and spiral often is only a few inches. The practice of using a great number of vertical bars, 8 or more, to prevent a flow of the highly stressed hooped concrete is not warranted by these tests, and the flow is more positively prevented by a small pitch.

Dr. Emperger has used composite concrete sections of rectangular shape for ribs in a number of important arch bridges, and had tests made on rectangular columns with rectangular spirals of close pitch, containing about 10 per cent of cast iron core. He tested a number of sections of 9-in. x 19-in., having a kind of I-section of cast iron with large openings in the web, the cast iron representing 11 per cent of the section. The l/d was 14.4, the l/r was 84 and the ultimate load per sq. in. which the cast iron core supported was figured at 42,000 lb. The same sections loaded with an eccentricity of ⅓ the depth supported a load of ⅔ the concentrical load. Such composite compression members are of great advantage in arched bridges of great spans. Instead of plain reinforced concrete ribs of an ultimate strength of about 3000 lb. per sq. in., composite ribs can be designed for 18,000 lb. per sq. in. and more. The lighter section of the ribs not only reduces the cost of the abutments and that of the form work, but very materially decreases the stresses due to shrinkage or a drop in temperature. Deflections and settlements of the abutments cause very much smaller stresses in small crown sec-

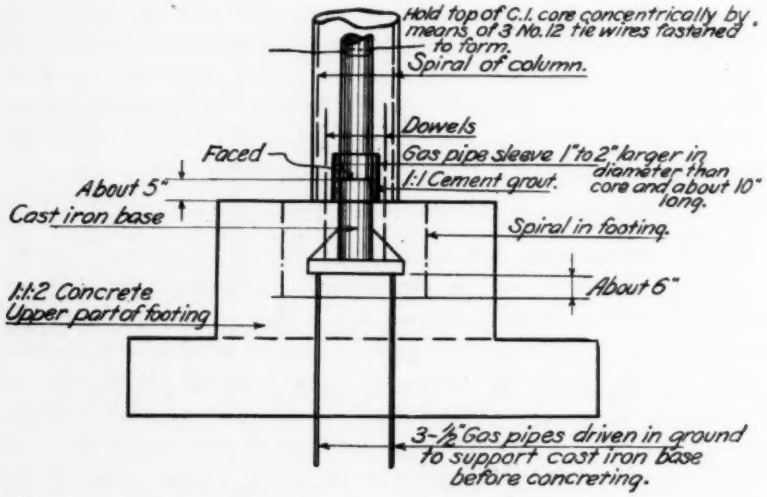
Hold top of C.I. core concentrically by means of 3 No. 12 tie wires fastened to form.
Spiral of column.
Dowels
Faced
Gas pipe sleeve 1" to 2" larger in diameter than core and about 10" long.
About 5"
1:1 Cement grout.
Cast iron base
Spiral in footing.
About 6"
1:1:2 Concrete Upper part of footing
3-½" Gas pipes driven in ground to support cast iron base before concreting.

FIG. 5—TYPICAL FOOTING FOR COMPOSITE COLUMN

tions than in large ribs and make the introduction of hinges almost superfluous. Engineers are enabled to use arch bridges in localities where rock foundations hitherto considered necessary for every arch bridge, are not available for the abutments. It is also an easy matter to design the metal core for the support of the suspended formwork, thereby reducing the cost of this most important item to perhaps one third. Dr. Emperger has built a number of bridges from 200 to 300 ft. span in competition with wooden bridges and nearly all his bridges had abutments supported by piles. He obtained patents for his system of composite sections in nearly all civilized countries. The author has made designs for heavy bridges up to 1000 ft. span and found their cost considerably lower than steel or common concrete bridges of the same total length and divided into two or three spans.

In the practical design of composite columns the load from the metal core is transmitted to the footing by means of a cast iron base, as shown in Fig. 5. The upper part of the footing is made of 1:1:2 concrete and is strengthened by a spiral of about 4½ times larger than the core. The load from the core is transmitted

TABLE V

COMPARATIVE DESIGN OF EMPERGER COLUMNS AND STANDARD HOOPED CONCRETE COLUMNS FOR A TALL BUILDING ACCORDING TO THE CHICAGO CODE.

	Emperger Columns					Standard Hooped Concrete Column		
	Load in 1000 lbs.	Side of Sq. Col.	Per cent of Spiral	Verticals	Dia. of Solid Cast Iron Core	Side of Sq. C.	Per cent of Spirals	Verticals
22nd Story	100	25″	ties	4— ⅞″ rd.		18″		4— ¾″ rd.
	160	25″	ties	4— ⅞″ rd.		18″	½%	8— ⅞″ rd.
	220	25″	ties	4— ⅞″ rd.		18″	1½%	8—1″ sq.
	280	25″	½%	8— ¾″ rd.		22″	1½%	8—1″ rd.
	340	25″	1 %	8— ¾″ rd.		22″	1½%	8—1¼″ rd.
	400	25″	1½%	8—1 ″ rd.		22″	1½%	11—1¼″ sq.
	460	25″	1½%	8—1¼″ sq.		26″	1½%	8—1¼″ sq.
15th Story	520	25″	1½%	10—1¼″ sq.	2½″	26″	1½%	13—1¼″ sq.
	570	25″	1½%	10—1¼″ sq.	3½″	26″	1½%	16—1¼″ sq.
	630	25″	1½%	10—1¼″ sq.	4½″	30″	1½%	10—1¼″ sq.
	690	25″	1½%	10—1¼″ sq.	5½″	30″	1½%	12—1¼″ sq.
	745	25″	1½%	10—1¼″ sq.	6″	30″	1½%	16—1¼″ sq.
	802	25″	1½%	10—1¼″ sq.	6⅝″	30″	1½%	20—1¼″ sq.
	870	25″	1½%	10—1¼″ sq.	7⅝″	30″	1½%	24—1¼″ sq.
	930	25″	1½%	10—1¼″ sq.	8″	34″	1½%	16—1¼″ sq.
	985	25″	1½%	10—1¼″ sq.	8⅝″	34″	1½%	20—1¼″ sq.
	1020	25″	1½%	10—1¼″ sq.	8⅝″	34″	1½%	23—1¼″ sq.
	1070	25″	1½%	10—1¼″ sq.	9″	34″	1½%	26—1¼″ sq.
	1152	25″	1½%	10—1¼″ sq.	9⅝″	38″	1½%	20—1¼″ sq.
	1215	25″	1½%	10—1¼″ sq.	10″	38″	1½%	24—1¼″ sq.
	1280	25″	1½%	10—1¼″ sq.	10¾″	38″	1½%	29—1¼″ sq.
1st Story	1350	25″	1½%	10—1¼″ sq.	11″	38″	1½%	34—1¼″ sq.
Basement	1420	25″	1½%	10—1¼″ sq.	11⅜″	38″	1½%	43—1¼″ sq.

From above data it is found that, assuming all columns to be 11 ft. high in each story,

Emperger columns contain:
1,100 cu. ft. of 1:1:2 concrete,
3,114 lb. of spirals
13,750 lb. of vertical steel
2,112 sq. ft. of forms, and
29,293 lb. of cast iron

Standard columns contain:
1,574 cu. ft. concrete
7,255 lb. of spirals
29,535 lb. of vertical steel
2,460 sq. ft. of variable forms.

by bond on the shaft of the base and by direct compression of about 1000 lb. per sq. in. on the plate. The direct stresses from the hooped concrete of the basement column can be assumed to spread out in the shape of a cone between the base plate and the footing spiral. Before the cast iron base is set, three ½-in. gas pipes are driven into the ground to the correct elevation of

the under side of the plate and the base is lowered to the proper level. The shaft of the base is made long enough to project 5 in. above the finished footing, and after the footing is concreted a gas pipe sleeve, one or two inches larger in diameter than the core, is placed concentrically over the protruding shaft and filled with cement grout of 1:1 mix to about ¼ in. below the top of the shaft. After the basement column form and the spiral and vertical rods are in place, the gas pipe sleeve is partly filled with grout by pouring from the top of the form and the metal core is lowered into the sleeve by means of a gin pole, the grout acting like a mirror, thus enabling the setter to center the core. Sometimes ¼ in. rods are placed in the space between the core and the sleeve to facilitate centering. The grout fills the space between sleeve and core, and to assure that no gravel has lodged between the faces of the cores, the upper core is turned a few times to the right and left to crush it. The top of this core projects 5 in. above the first floor and the connections on each floor are made with sleeves as described for the basement story. The top of the core is held in place by 3 wires connected either to the columns or floor forms.

It is important for engineers to know what size column to adopt to obtain an economical and practical design. They have to be guided by the fact that a great saving in the cost of the entire skeleton can be effected by making all columns of each column stack of the same size, and if possible use only one or at the utmost two or three column sizes in the entire structure. It is very much easier for the contractor to build all his column forms on only one or two benches without change of templates; he will not need special foremen to superintend the rebuilding of forms story by story. Neither will he have to rebuild the girder and lintel forms. He will need only two sets of column forms and not more than two sets of lintel forms even if his progress is at the rate of three stories per week, because he does not lose any time for rebuilding. Hence less talent has to be spent on the form work and more time is left for the leaders to see that good work is done on the concreting, and competent contractors will soon learn that they can do the form work for columns, girders and lintels for at least 5¢ per square foot less than in the old system with its repeated changes of form.

Experience has shown that a composite column stack with the same size of columns from top to bottom, costs less than a column stack with standard hooped concrete columns of varying sizes, when the basement columns are designed for about 4000 to 5000 lb. per sq. in. on the area within the spiral hooping. Table 5 shows such a comparative design for a 22-story building which has been constructed in the City of Chicago.

When the composite columns are made larger the cost is less, and when they are made smaller than shown in Table 5 their cost may become slightly higher than that of standard hooped concrete columns.

In order to solve the question of bond of the cast iron core with the hooped concrete, the writer had tests made by Prof. D. A. Abrams on smooth 2 in. bars 12 and 24 in. long, embedded in a 7-in. diameter hooped concrete block. The results of the tests were not published. The bond stress at failure was found to be from 900 to 1200 lb. per sq. in., and confirmed similar results found by Considere on gas pipes embedded in hooped concrete.[3] The bond stress is so much higher than in plain concrete because the hoopings prevent the concrete from splitting up. This high bonding value enables the metal core to take up in the depth of a girder the heaviest loads any girder or number of girders ordinarily transmit to a column in any one story; hence brackets or rings on the core beneath the girders are unnecessary. Engineers often inquire how the reinforced girders are connected to the columns. There is hardly any difference between this type of column and the ordinary concrete column, especially as the modern tendency is to make girders not much deeper than the joists framing into them. This requires that the girders be made wide, preferably as wide as the columns for economy in form work, which enables most of the straight and bent bars to pass by the cores, as there is nearly always at least 5 in. of concrete outside the cores. In special cases it may be necessary to use two or more extra bars for the negative moments at the columns. In a number of cases steel girders have been connected to brackets on the cores and

[3]Commission du Ciment Armé. Rapport etc. 1907.

in one case trusses, carrying over a million pounds, have been set on top of the cores.

It is the writer's practice to use as longitudinal reinforcement from 2 to 4 per cent of high carbon bars to take care of any bending moment which may be exerted on the columns. Because the loads are very large on composite columns, the eccentrity produced by connecting girders is not as a rule of great amount. It is different, however, with columns forming part of a wind

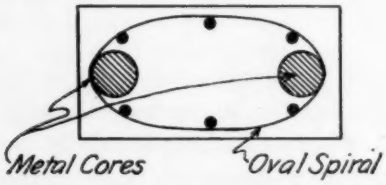

FIG. 6—SECTION OF COMPOSITE COLUMN FORMING PART OF WIND BRACING SYSTEM

bracing system. There the eccentricity of loading may be as large as 6 to 9 in., and such columns act similarly to the ribs in an arch bridge, and a design as shown in Fig. 6 will be more economical in buildings higher than 20 stories. Nearly all columns tested by the writer showed eccentricities of loading which varied from 1/20 to 1/10th of the diameter of the spiral; hence, engineers need not be too anxious about small eccentricities.

A comparison between composite columns with cast iron cores and structural steel cores might be of interest to the profession. Let us assume a column 15 ft. high has to support a load of 2,000,000 lb. Adopting the rule proposed by the writer we shall allow for 1:1:2 concrete with 1 per cent spiral, a stress of 1250 lb. per sq. in., and 10,000 lb. minus 1250 lb. or 8750 lb. per sq. in. on the vertical steel. Adopting a spiral of 22 in. we find the l/d equals about 8, hence the permissible stress on the core is 12,000 lb.—1250 lb. or 10,750 lb. per sq. in. The area of the 22-in. concrete core is 380 sq. in. and the area of eight 1¼-in. square bars, representing about 3 per cent of the area inside the spiral is

12.5 sq. in., hence the load carried by the hooped concrete is 380 x 1250 lb. = 475,000 lb.; by the vertical steel 12.5 x 8750 lb. = 109,000 lb., giving a total of 574,000 lb. Hence the metal core has to carry a load of 2,000,000 lb. — 574,000 lb. = 1,426,000 lb., requiring a sectional area of 1,426,000 divided by 10,750, or

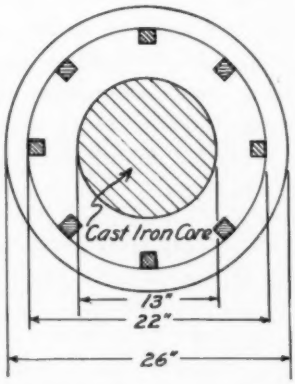

FIG. 7—SECTION OF COMPOSITE COLUMN WITH CAST IRON CORE

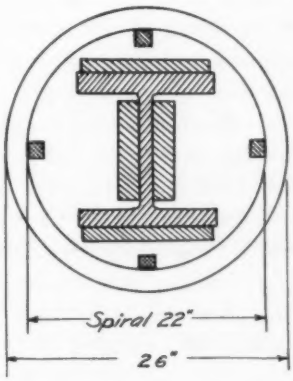

FIG. 8—COMPOSITE COLUMN WITH STEEL CORE OF BETHLEHEM H-COLUMN WITH COVER AND WEB PLATES

132.5 sq. in., equivalent to a cast iron core exactly 13 in. in diameter. The l/r will be about 55, and we may expect this core to fail at a stress of about 50,000 lb. per sq. in., if made of common grade of cast iron. This cast iron core will weigh about 425.0 lb. per lin. ft. A Bethlehem 16-in. H-column section would have about 126 sq. in. but cannot be used in any spiral less than 28 in. in dia., hence we have to use a 12 in. H-section weighing 190 lb. per lin. ft. and reinforce it with two cover plates 12 in. x 1¼ in. and two web plates 9 in. x 2 in., giving a total area of 121 sq. in. and weighing about 435 lb. per lin. ft. This section has about 9 per cent less area than the cast iron core, but is heavier, and costs, of course, a great deal more. Both sections are shown in Figs. 7 and 8. While cast iron cores can be shipped within 3 days, deliveries of structural steel cores would require

a great deal more time. If composite columns come into vogue it will, of course, be possible to get round sections rolled on short order.

An inspection of Fig. 7 will show that composite columns are more nearly fireproof than fireproofed steel columns because there is as a rule at least 5 in. of concrete outside of the metal core, and the core alone can support the load with a good factor of safety, even if the concrete is entirely destroyed. Composite columns have also been used in low buildings where small sizes of columns are of importance, such as garages and certain manufacturing buildings, or where the contractor appreciates the saving of form work in having all columns in the building of the same size. Engineers, also, ought to appreciate the savings in their own time of preparing column schedules. When all columns are the same size, and spirals and vertical steel are alike, the schedule will have to show only the size of the core for each story, and a simple note will take care of the spiral and vertical rods for most of the columns.

Readers are referred to the JOURNAL *for March 1931 for discussion which may develop. Such discussion should reach the Secretary by February 1, 1931.*

Specifications For Ready-Mixed Concrete

Proposed American Concrete Institute Specification No. 504

MILES N. CLAIR,* AUTHOR-CHAIRMAN

Committee 504, Specifications for Ready Mixed Concrete

1. General

(A) These specifications cover the special conditions affecting the use of Ready-Mixed Concrete and supplement the requirements of the General Specifications for Plain and Reinforced Concrete for this Contract.

(B) The term "Ready-Mixed Concrete" is used in these specifications as meaning[1] Central Plant-Mixed concrete and Central Plant-Proportioned Truck-Mixed concrete.

(C) The place where the materials are proportioned is referred to in these specifications as "the plant."

(D) The operation of the plant shall be under the direct supervision of a competent engineer.

2. Materials

(A) All aggregates, cement and water shall be of the quality required by the General Specifications for Plain and Reinforced Concrete. All conveyors, bins and hoppers shall be cleaned of unapproved materials before starting to manufacture concrete for this contract.

(B) No change shall be made in the materials used, during the course of this contract, except with the permission of the Architect or Engineer.[2]

3. Concrete quality and proportioning

(A) The concrete quality and proportions shall be in accordance with the requirements of the General Specifications for

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[1]The Architect or Engineer must indicate which systems are allowed. It is recommended that in general both be included.

[2]In the use of this specification for a particular project one of these must be stricken out throughout the text to avoid conflict.

Plain and Reinforced Concrete. Proportions, however, shall be subject to change under the direction of the Architect or Engineer when necessary to produce proper workability or satisfactory strength.

(B) The measurement of the concrete aggregates and the cement[3] shall be by weight so that the proportions can be readily adjusted to assure a definite volume of concrete of the quality specified. The measurement of the water may be by weight or volume. The volume of concrete produced per batch shall be taken as the sum of the absolute volumes of the ingredients.

(C) A statement of the control quantities[4] used and the time at which the vehicle was loaded shall accompany each load of concrete. The organization supplying the ready-mixed concrete shall have available sufficient test data, certified by a competent concrete testing engineer, to enable the Architect or Engineer to determine whether the quantities used will give concrete of the desired quality and the stated quantity per batch.

(D) Facilities shall be provided at the plant to enable the Architect or Engineer to check easily at any time the quality of the materials and the accuracy of the measurements.

(E) Tests of the concrete as delivered to the forms shall be made during the progress of the work as required by the General Specifications for Plain and Reinforced Concrete.

4. MIXING AND TRANSPORTING CONCRETE

(A) *General*

(1) Transporting vehicles shall be so constructed as to insure rapid delivery without loss of ingredients.

(2) All concrete shall be mixed in a revolving drum type of mixer, whether stationary or movable. The mixing time or number of revolutions shall be as recommended by the manufacturer; but shall not be less than required by the General Specifications for Plain and Reinforced Concrete. The mixer shall not be loaded beyond the capacity recommended by the manufacturer.

[3]Bag measurement may be used provided the batches do not involve fractions of bags.
[4]"Control quantities" refers to the requirements of the specifications such as water-cement ratio, cement content, or proportions.

(3) A maximum period of 00 hours[5] may elapse between the addition of the cement to the aggregate and the placement of the concrete in the forms; but the concrete as placed shall be of the consistency and workability required by the General Specifications for Plain and Reinforced Concrete.

(4) Under no circumstances shall partially hardened or retempered concrete be placed in the structure.

(5) Special precautions shall be taken to protect the materials from damage during transportation under extreme weather conditions.

(B) *Central Plant-Mixed Concrete*

(1) The concrete shall be properly mixed in accordance with the requirements of the General Specifications for Plain and Reinforced concrete before being loaded into the transporting vehicle.

(2) Non-agitating type transporting vehicles shall not be used to transport Central Plant-Mixed concrete when the consistency of the concrete is wetter than a —-inch slump.[6]

(3) Remixing type transporting vehicles[7] shall not be used to transport Central Plant-Mixed concrete when the consistency of the concrete is wetter than a —-inch slump.[6]

(4) Agitating type transporting vehicles may be used without restriction as to consistency.

(C) *Central Plant-Proportioned Truck-Mixed Concrete*

(1) The procedure in loading the truck mixer[8] shall be such that the cement and aggregates are uniformly distributed throughout the batch when the loading is completed.

(2) Where the concrete is mixed during transportation of the batch to the job, means shall be provided so that the mixing time

[5]The Architect or Engineer must indicate the limiting period. A maximum period of one hour is recommended. (The committee is not unanimous. One group approves of the limit of one hour, as given. The remainder of the committee approves a statement in the footnote referring to this item as follows: "Present knowledge of the art indicates that the time may be as long as three hours under favorable conditions. It should be limited by the engineer or architect after a study of job conditions, kind of aggregates, and the prevailing temperature and weather conditions at the time the structure is being erected.")

[6]The Architect or Engineer must indicate the limiting slump. A maximum allowable slump of 2½ ins. for non-agitating type trucks and 6 in. for remixing type trucks is recommended.

[7]Re-mixing vehicles are those provided with special means of remixing or agitating the concrete to some degree during discharge but not during transportation.

[8]It is suggested that the cement and aggregates be fed simultaneously into the end loading type of truck mixer. For the top loading type of mixer this method of charging is not so essential; but is also recommended.

and the quantity of water added can be readily verified by the Architect or Engineer.

5. DELIVERY

(A) The organization supplying concrete shall have sufficient plant capacity and transporting apparatus to insure continuous delivery at the rate required.

(B) The interval between loads shall not exceed — minutes,[9] or in any case be so great as to allow the concrete in place to become partially hardened.

(C) The methods of delivering the concrete shall be such as will facilitate placing with the minimum of re-handling and without damage to the structure or concrete.

DISCUSSION

BY THE AUTHOR-CHAIRMAN

The specifications for Ready-Mixed concrete presented herewith to the Institute for tentative adoption have been developed after considerable discussion, among the members of the committee and others of the proposed specification published in the JOURNAL for February, 1930.* The questions about which the discussion centered are:

(1) Should the specification be considered as a complete specification in itself or as a supplement to a general specification for plain and reinforced concrete?

(2) Should separate specifications be developed for Central Plant-Mixed Concrete and for Central Plant-Proportioned Truck-Mixed Concrete?

(3) Should special limitations be placed on the methods of measuring materials?

(4) What limitations should be set up for the use of the various types of transporting vehicles and mixers?

The decision of the majority of the committee is apparent from the specifications here proposed; but some discussion and explanation may be of value in connection with its proper use.

*A. C. I. *Proceedings*, Vol. 26, p. 467.

[9]The Architect or Engineer must indicate the interval allowed. A maximum of thirty minutes is recommended.
(The committee is not agreed as to the consistency or slump limitation. The group in opposition to the form proposed desires something as follows in the footnote. "The Architect or Engineer must indicate the limiting slump. Practice indicates that while there are definite limitations to this type of transportation, the limiting slump will be determined by the particular type of equipment used, the nature of the mix, the length of haul, and the character of the road over which it is to be hauled."

Most Architects or Engineers use a standard general specification for plain and reinforced concrete based on the Joint Committee Report. That specification is relatively complete in regard to requirements for materials, proportions, mixing, quality of concrete, placing of concrete, and other items. The requirements necessary under most of these items for Ready-Mixed concrete are no different to secure good concrete than for job-mixed concrete. The Architect or Engineer is still conservatively inclined to use job-mixed concrete rather than the recently developed ready-mixed concrete; and, therefore, a specification that supplements his present general specification with additional safeguards has special appeal. The additional complication of separate specifications for central-plant-mixed concrete and central-plant-proportioned-truck-mixed concrete seems at this time unnecessary. Possibly abuses or future developments may later warrant such a separation.

The specification proposed is, as stated in its first paragraph, intended for use as a supplement to the General Specifications for Plain and Reinforced Concrete for a particular contract; and, therefore, only such special requirements are given as appear necessary to insure concrete of the quality desired. The conception of a specification as a statement of the results desired rather than of the methods or equipment to be used is adhered to as far as possible. It is considered the function of another department of the Institute to set up requirements for equipment and procedure to meet these specifications. The specifying of the supervision of the plant operation by a competent concrete engineer is considered necessary because the plant must be ready to produce on almost instant demand concrete to meet any one of many specifications. A technical education combined with considerable field experience with concrete construction and the control of concrete quality are essential requirements for such a supervising engineer.

Two special requirements are set up in regard to materials. The ready-mixed concrete plant in general has a tie-up with definite material sources which will satisfy the usual specifications. Special materials are required for some work, however, and contamination by usual materials must be prevented. Like-

wise, change of source of materials during the course of the work must be subject to approval by the Architect or Engineer so that not only the quality but also the appearance will not vary.

Although most general specifications for plain and reinforced concrete at present set up requirements in terms of strength, cement content, water-cement ratio, and workability, and do not closely limit proportions, the concrete as produced by the ready-mixed concrete operation may call for changes which the Architect or Engineer should be free to make. The requests for such changes will, however, most frequently come from the plant operator who knows from experience the best combinations, for his equipment and conditions, to meet certain requirements. Changes as requested by the concrete foreman on the job should never be made without the approval of the Architect or Engineer.

A ready-mixed concrete plant cannot accurately meet the demands of numerous specifications and pre-determined quantities unless the aggregates are weighed. The entire operation becomes simplified if all the materials including cement and water are weighed. One of the principal causes of controversy in regard to ready-mixed concrete is the basis on which the volume of concrete delivered shall be measured. Direct measurement in most cases is not possible; but if weight proportioning is used, the yield as computed from the absolute volumes of all the materials is sufficiently accurate and will closely agree with direct measurements.

The Architect or Engineer on the usual construction project can at any time readily go to the mixer and check up on the mix. He also generally has some check on the amounts of materials used, and so will know whether the concrete is nearly of the mix required. The ready-mixed concrete plant is almost always at an appreciable distance from the job; and, therefore, a statement of the basic control quantities used for each load is desirable. These quantities can be used not only as a check on proper quality and quantity, but also to enable the Architect or Engineer to estimate, from the test data and records of batch quantities available at the plant, the probable strength at any given period.

The ready-mixed concrete operation differs from the usual job concrete procedure mainly in the mixing and transporting of the

concrete. The central-plant-mixed concrete system mixes in a regular mixer of a large size, and transports the concrete to the job in ordinary trucks or special trucks. No comments are necessary in regard to the mixers except that they are usually of larger sizes than is common for job set-ups; and, therefore, the mixing time required is generally greater. Minimum mixing times of one minute for a one-yard mixer, 1½ minutes for a two-yard mixer, and two minutes for a three-yard mixer, are recommended. The conveying vehicles should be water-tight so that no ingredients of the mix are lost. Agitator trucks should be designed so that they really do keep the concrete mixed throughout the truck. Overloading of agitator trucks results in decided decrease of efficiency of the mixing action.

Central plant-proportioned-truck-mixed concrete requires special mixing and conveying equipment. Some of the truck mixers are essentially the same as the standard mixers of low length-diameter ratio; but the more common type is of high length-diameter ratio. These truck mixers also range to sizes as large as five cubic yards. Experience has indicated that a mixing time of five minutes, or better 40 revolutions, is necessary for such mixers. There is plenty of time for such mixing during the trip to the job. Some end-loading types of mixer trucks also require special care in loading to assure uniform distribution of the materials, unless excessively long mixing time is used. The truck mixer type of operation puts the mixing and water measuring operations in the hands of the truck driver, if done on the way to the job; and, therefore, some means of readily checking up on these operations should be provided.

The Architect or Engineer is most concerned when using ready-mixed concrete that the concrete comes to him in a homogeneous mix and without damage due to the time elapsing in transportation. Transportation of the concrete in an ordinary truck that may be used at other times for sand and gravel appeals to the ready-mixed concrete plant operator because of its low cost. Experience, however, has shown that concrete wetter than a 2½-in. slump cannot be transported in such trucks without segregation and consequent difficulty in unloading and detriment to the quality of the concrete. Under special conditions of mix, ma-

terials, or very short hauls, wetter concrete has been successfully handled; but such cases are not usual.

Agitator type trucks are satisfactory for concrete of any slump likely to be used. Most agitators keep the concrete well-mixed despite the surprisingly small amount of movement given the mass. Improvement in the design of some agitator trucks is desirable, however, to insure a more uniform mixing action, particularly where several batches are used to fill one truck.

Most architects and engineers agree that concrete that has partly hardened should not be used. What is meant by "partly hardened" is difficult to define; but it is more readily determined in practice, as such concrete has a peculiar crumbly appearance when mixed which is different from concrete that is just dry. The limit to be set on the time elapsing between the addition of the cement to the batch and the placing of the concrete in the work will depend on many factors; and cases have been cited to favor a shorter or longer period. Without tests for a particular set of conditions, it is recommended that a maximum elapsed period of one hour be allowed. This is considered as properly applying to truck mixing operations as well as to central plant mixing, because the water in the aggregates in the former operation is available for action with the cement.

The section of the specification on Delivery is intended to safeguard the work from delay due to failure of the ready-mixed concrete supply. It might in many cases well include a requirement of a bond to insure proper service and to cover damages.

The writer is considerably indebted to the critic members of this committee for their suggestions, criticisms and interest. Unanimous agreement in regard to all items was not possible or expected as the use of Ready-Mixed Concrete is comparatively new. Changes in any specification will be made as experience in the field concerned gives more facts on which to base conclusions. It is hoped that this specification will be considered of sufficient merit to be given a working trial as a Tentative Standard Specification.

Readers are referred to the JOURNAL *for March, 1931, for discussion which may develop. Such discussion should reach the Secretary by February 1, 1931.*

Discussion of Report of Committee 604

"Winter Concreting Methods"*

BY I. E. BURKS AND G. D. DURHAM†

It was not so very many years ago that constructors faced with the necessity of placing concrete in freezing weather, attacked the problem with apprehension and doubt. There seemed to be a feeling that a structure erected under such conditions *might* be satisfactory and a fair chance that it might *not* be. Today, thanks to the information made available through the publications of various technical societies, and through the experiences of individual engineers and constructors, we are able to attack a concrete job at 30 or 40 degrees below zero with a feeling of absolute confidence in the results—*if certain rules of the game are carefully followed.*

It is certainly true that there are a few examples of partial failure, directly attributable to frozen concrete. There are also dozens of noteworthy examples of excellent concrete work done at extremely low temperatures. Committee 604 hopes to be successful in correlating the experience and observation of constructors responsible for the successful operations and also the failures. Mr. Johnson, in his preliminary report, has paved the way for writing recommended practice which may eventually be adopted as standard by the Institute, and which may be followed with confidence and safety by engineers and constructors.

In his report as author-chairman of the committee, Mr. Johnson limits its scope to concrete construction in ordinary buildings —but, he points out that the principles involved are equally appli-

*By Robert C. Johnson, as author-chairman of committee 604, Winter Concreting Methods, published in the Journal, Feb. 1930—A. C. I. *Proceedings*, Vol. 26, p. 397. See also discussion Journal, June 1930—*Proceedings*, Vol. 26, p. 904.

†Mr. Burks is concrete technician for the Aluminum Company of America, member of Committee 604 and wrote "Concreting Methods at the Chute a Caron Dam" (in the Journal for Feb. 1930—A. C. I. *Proceedings*, Vol. 26, p. 315) where concrete was placed at 40° below zero. Mr. Durham is his associate on that work.

cable to other types of construction less difficult to protect. For the purpose of this discussion, perhaps it would be helpful to divide all concrete work into two general classes, viz., Reinforced Frame Sections, and Heavy Mass Work. We agree that the principles of protection are the same for either of the classes named but suggest that the objective may be slightly different. To cure concrete for such a time as simply to protect it from damage by freezing is one objective; to cure it for an additional period in order that it may attain a specified strength at a designated time, is another objective. The first is usually the only requirement in heavy mass work. The second, is generally an important and necessary consideration in reinforced frame construction.

If concrete freezes before it solidifies, the uncombined water forms small ice crystals throughout the mass. If it is thawed and thoroughly cured at temperatures above 50° it will attain a strength equal to from 75 to 95 per cent of its potential strength. It has often been stated that *one* such freezing does little if any permanent damage to the concrete, nevertheless, as pointed out by R. B. Young,[1] it is difficult to conceive that the pores formed by the ice crystals are all entirely closed and the mass consolidated as it would have been had freezing not occurred. From this it is evident that the greatest damage done by freezing occurs after the concrete begins to solidify or harden.

The length of time that concrete should be cured to prevent its being damaged by freezing, depends mainly on four factors: (a) type of cement; (b) richness of mixture; (c) amount of heat supplied by the aggregates and mixing water; (d) temperature of the air within the protective enclosure.

In heavy mass construction, the safe protection rule is to provide means of maintaining the temperature of the green concrete near exposed surfaces, above 50° F. until it has attained sufficient strength to withstand frost action. In general it may be stated that concrete designed to have compressive strength of from 1500 to 2000-lbs. per sq. in. at 28-days should be kept at or above the temperature stated until 40 per cent of the designed strength is developed—2000 to 3000-lb. concrete should have 30 per cent, and 3000 to 4000-lb. concrete should have 20 per cent

[1]Discussion of Report of Committee 604—A. C. I. JOURNAL, June 1930—A. C. I. *Proceedings*, Vol. 26, p. 904.

of its designed strength before the temperature of sections near the surface is allowed to fall below 50° F. In gravity dams, high strength is desirable but it is not essential and curing is largely directed to obtain a surface that will withstand the weathering action of the elements. The surface area is small as compared to the mass and the heat loss by radiation is small—consequently the heat developed by the hardening concrete is retained for a longer period.

In thin reinforced frame work, the concrete may be protected until the danger by freezing is eliminated and still not attain its designed strength at the 28-day period. Consequently, there is a possibility of damage by premature loading unless proper protection is provided to meet the requirements of individual cases.

Small walls and structural members encountered in building construction offer a very definite structural hazard when subjected to freezing. The problem of protection and curing is to enable these members to obtain their designed strength before being loaded. In proportion to their mass the surface is great—hence the heat developed by the chemical reaction of the hydration of the cement plus the heat supplied at the mixer, is readily dissipated by the lower air temperatures. Therefore, in thin reinforced frame construction, the forms must be covered and the enclosure maintained at a temperature sufficiently high and for a period long enough to insure the development of the required strength.

On the work on which the authors are engaged,[2] a series of preliminary tests was made to determine the length of time it is necessary to cure concrete placed at temperatures considerably below the freezing point. The experiments were made by the field laboratory organization in the winter of 1929-30 when it was convenient to take advantage of the low atmospheric temperatures for freezing the specimens. The work had to be temporarily discontinued in the early Spring of 1930 because of temperature conditions, but it is to be resumed in the Winter of 1930-31. The series on which results are available at this time includes only one water-cement ratio—viz., 0.80. The second series is to be made using a water-cement ratio of 1.0.

[2]Chute a Caron Dam, Province of Quebec, Canada.

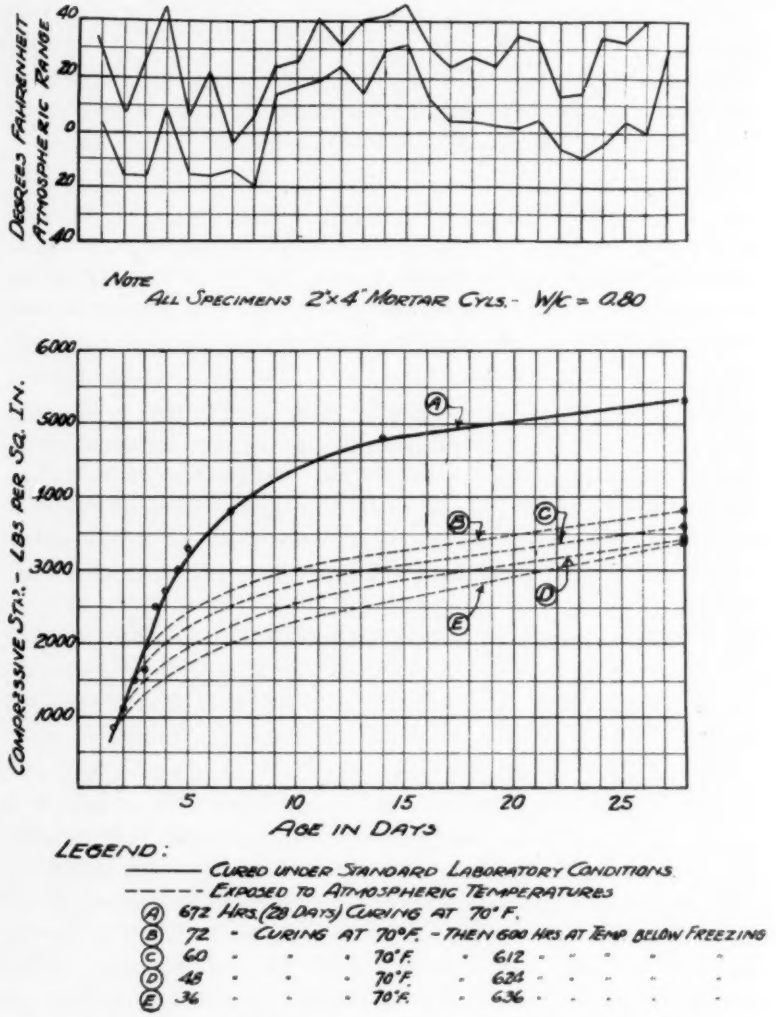


FIG. 1—EFFECT OF EARLY CURING AT LOW TEMPERATURES ON 28-DAY STRENGTH

For convenience, and since comparative results only were required, all specimens made were 2 by 4-in. mortar cylinders, formed in accordance with standard practice. The specimens were cured for varying periods under standard conditions and then exposed to the existing freezing weather. The earliest breaking period was 36-hours. Breaks earlier than this were so low as to be of questionable value and were probably beyond the range of accuracy of the testing machine. All specimens were capped and allowed to remain in laboratory air (70°) one-hour before testing. Figs. 1, 2 and 3 show the results obtained. It should be pointed out that in these experiments the effect of freezing is magnified somewhat because the surface area of the test specimens used is so great in proportion to the volume.

In Fig. 1, Curve A represents the potential strength of a mortar at various ages up to 28-days when cured under standard laboratory conditions. Curves B, C, D and E indicate the strength of the same mortar when cured under standard conditions for 72, 60, 48 and 36 hours and then allowed to freeze for the remainder of the 28-day period. It will be noted that the frozen specimens acquired from 63 to 70 per cent of the potential 28-day strength.

Fig. 2 shows the same general strength relation as Fig. 1, except that all frozen specimens in this group were broken at the age of 7-days. It will also be noted that slightly different temperature conditions prevailed. In this group the specimens were cured at 70° for 36, 48, 60 and 72 hours and then allowed to freeze for the remainder of the 7-day period, show 55, 66, 71 and 75 per cent of the potential 7-day strength.

In Fig. 3 the specimens received the same early curing treatment as those in Figs. 1 and 2—but at the age of 7-days were returned to the warm air of the laboratory where they remained until the 14-day period, at which time they were broken. The direction taken by Curves L, M, N and O seems to indicate that at some period beyond the age of 14-days these curves would join the potential strength curve. It is regretted that this series does not include definite data on Curves L, M, N and O at the later ages, however, this is one of the series which will be developed further in the coming winter.

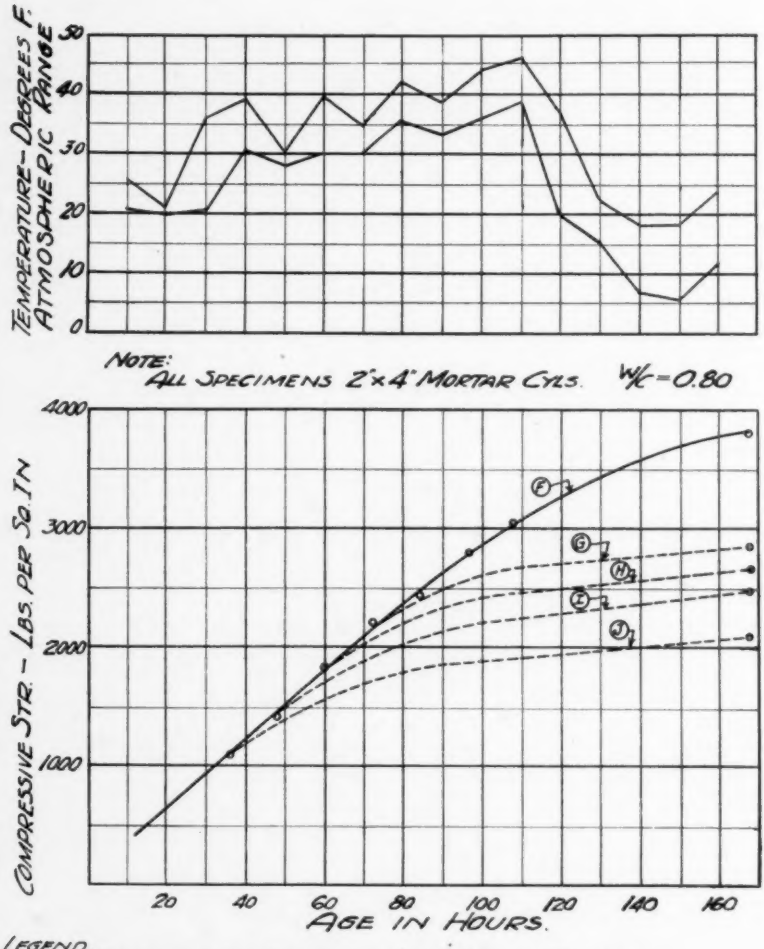
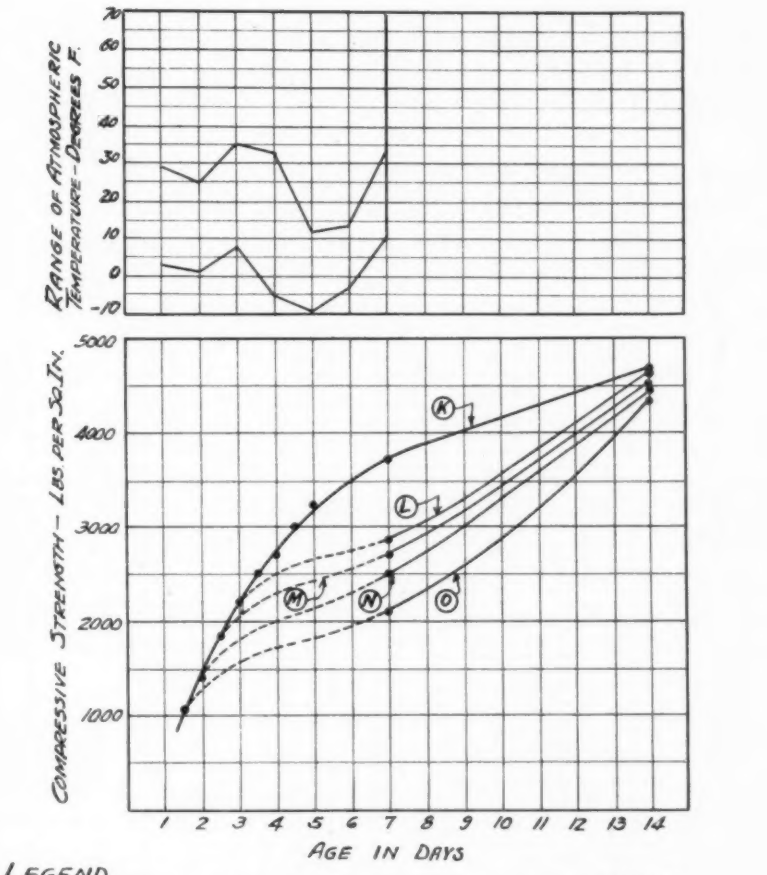


FIG. 2—EFFECT OF EARLY CURING AT LOW TEMPERATURES ON 7-DAY STRENGTH



LEGEND

CURED UNDER STANDARD LABORATORY CONDITIONS EXPOSED TO ATMOSPHERIC TEMPERATURES

(K)	336 HRS (14 DAYS)	CURING	AT	70° F.					
(L)	72 HRS.	CURING	AT	70°F.	- 96 HRS	BELOW	FREEZING -	168 HRS	AT 70°F.
(M)(L)	60	"	"	"	70°F.	-108	"	168	" " 70°F.
(N)	48	"	"	"	70°F.	-120	"	168	" " 70°F.
(O)	36	"	"	"	70°F.	-132	"	168	" " 70°F.

FIG. 3—STRENGTH GAIN WHEN CURED IN WARM AIR AFTER INITIAL CURING AT LOW TEMPERATURES

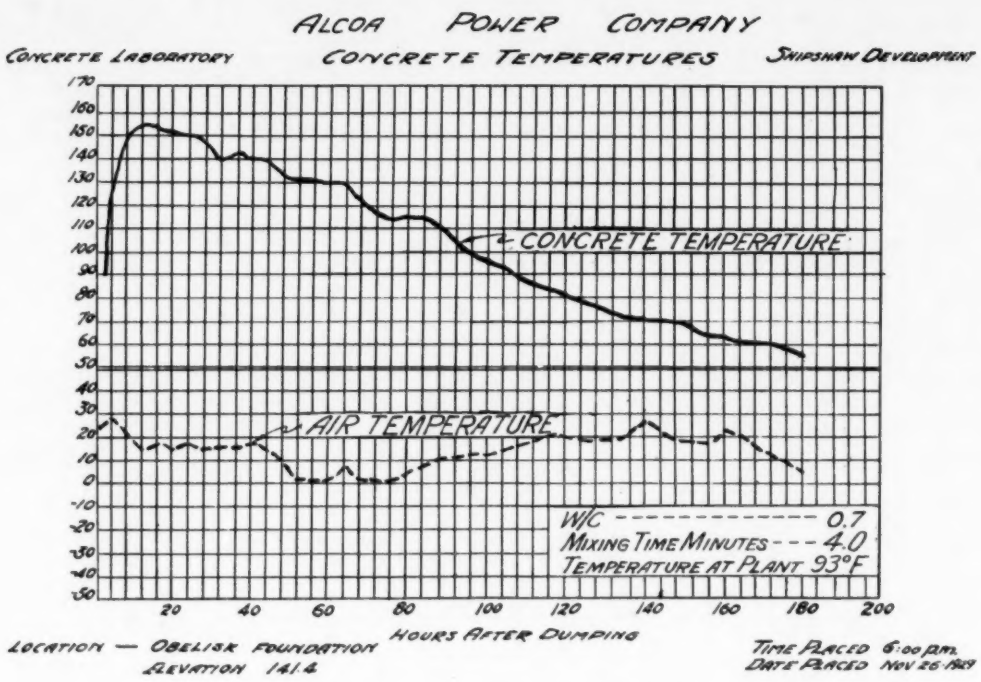


FIG. 4—TEMPERATURE RANGE OF MASS CONCRETE

During the time that the tests referred to above were being made, an arbitrary curing period of 72-hours was specified for concrete placed in all structures on the Chute a Caron project. By this is meant that adequate heat should be supplied, and proper covering provided to retain that heat, so that the temperature of the concrete 1-in. from the form faces would not fall below 60° for 72-hours after placing.

In general, this specification gave excellent results. In certain sections of the heavy mass work it was found that the form covering could be removed and the steam heat discontinued after 36-hours and the temperature of concrete near the exposed surfaces would still be 50 degrees or above at 72-hours after placing. On other smaller sections of the Power House work it was found necessary to keep the covering in place and the steam heat circulating for the full 72-hour period.

The chart, Fig. 4, gives a good idea of the temperature range on mass work. It will be noted that the concrete left the mixing plant at 93° F. The temperature began to rise immediately after placing and continued to do so until it had reached about 155° at 12-hours. It then decreased gradually until it reached 55° at 180-hours. In this instance the protective covering was kept in place for 60-hours.

It is not a difficult matter to work out a satisfactory type of form covering. Charles S. Hill, in his book "Winter Construction Methods" gives several excellent examples. The methods used at Chute a Caron Dam are shown in Figs. 5 and 6. It will be noted that practically the same type of covering is used on the small sections (Fig. 5) as on the heavy mass work (Fig. 6). The form sheeting is made of 2-in. lumber and this has considerable insulating value in itself. The covering for vertical faces consists of 4 by 10-ft. panels, burlap and tar-paper covered. These may be nailed to the main form walers, or placed about 18-in. back from the main form to provide a working space for pipefitters. A 1-in. steam line is run around the form at the bottom and at the center of each lift. The opening between the two forms is closed at the bottom to prevent upward draft. The top is covered by tarpaulins. Over large forms the tarpaulins are supported on

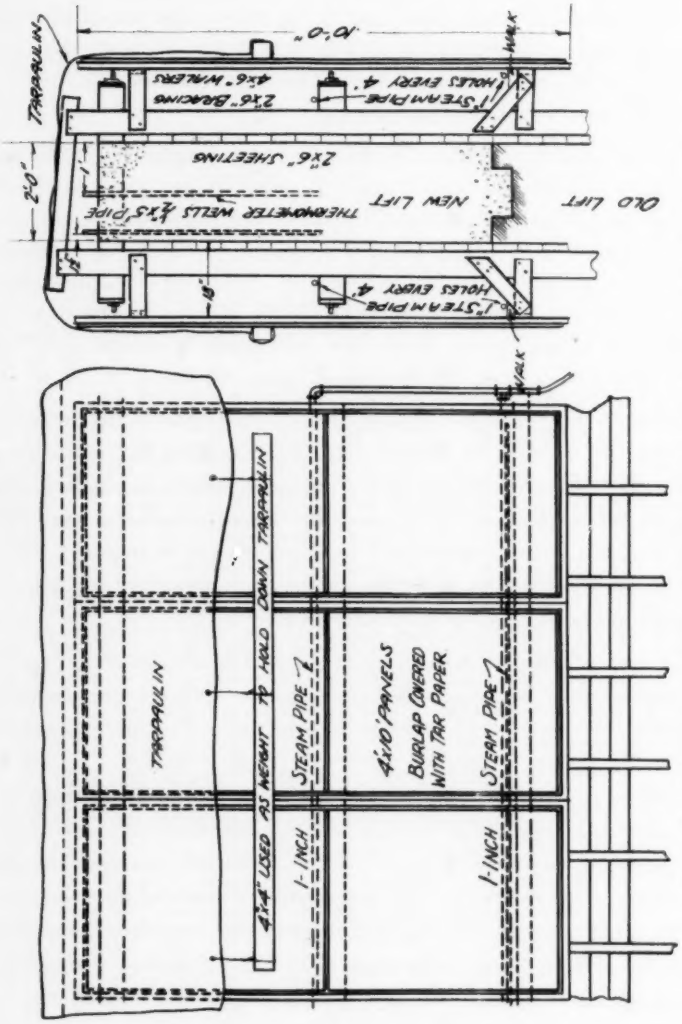


FIG. 5—METHOD OF PROTECTING SMALL SECTIONS OF CONCRETE

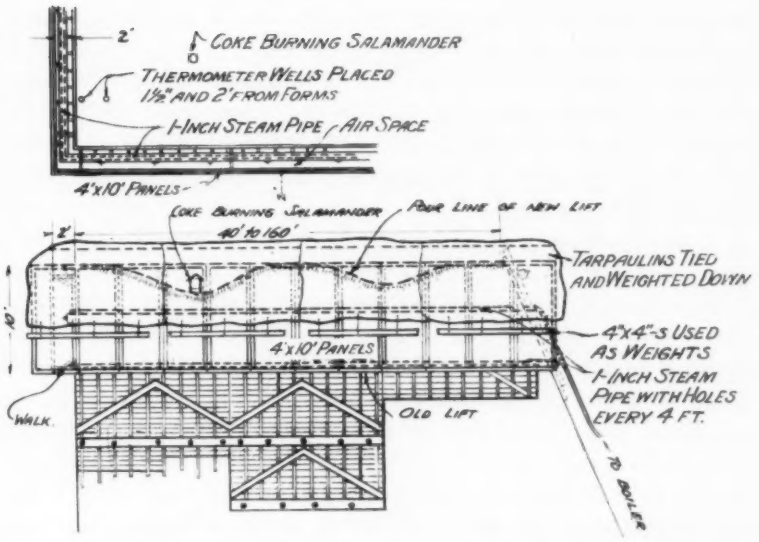


FIG. 6—METHOD OF PROTECTING HEAVY MASS WORK

light frame-work, and coke-burning salamanders are placed in the shear valleys, as shown in Fig. 6.

It is recognized that live steam, due to the moisture supplied, provides better curing protection than dry coils—however, it was found necessary to arrange the piping so that both types could be used on this work. If live steam is used while the placing is in progress, clouds of steam prevent the crews from seeing and the work becomes difficult and dangerous. Valves are placed at intervals in the coils so that dry heat may be supplied during the time the form is being filled, and then the valves are opened and live steam supplied when the form is finished and covered. Thermometer wells made of ½-in. water pipe, from 3 to 8-ft. long, are placed in the lift while the concrete is soft. These are normally located in three positions in the form; one at the up-stream face, one near the center and one at the down-stream face. Temperature readings are taken in these wells during the curing period.

When the air temperature is below the freezing point, necessary arrangements are made at the mixing plant to produce concrete having a temperature of from 70° F. to 100° F. It was found that concrete heated to above 100° was in danger of taking a flash-set. On two occasions when the mixture was discharged at 110° the concrete was set up in the buckets before it could be delivered to the forms (a matter of 25 or 30 minutes). This may have been caused by certain characteristics of the particular brand of cement used, or, it may have been caused by the manner in which the materials were introduced into the mixer drum. It has been suggested that if the cement came into immediate contact with mixing water at a temperature of from 180° to 200°, the chance of a flash-set would be much greater than when the mixing water had first been cooled to some extent by contact with the sand and stone. It is the opinion of the authors that there is no advantage in heating concrete higher than to 100°. This temperature offers ample protection for any ordinary transportation and placing system and has been found to be quite satisfactory where air temperatures are as low as 40° below zero.

Mr. Johnson has stated that concrete should be placed in the form at not less than 70° and not more than 140°. The lower limit would be quite satisfactory for reinforced frame-work, but it should be pointed out that temperatures from 10° to 15° lower than this can be used with safety on mass work where the air temperature is anywhere above zero. This is assuming that proper protection at the form is provided. His upper limit of 140° is open to question and there seems to be a great difference of opinion on the subject. The authors' views on this point have been stated in the preceding paragraph.

The matter of heating aggregates is not a serious problem where proper facilities are provided. It is probably a waste of time and money to try to heat the coarse aggregate at all. If enough stone or gravel is to be used to feed even a 3-bag mixer continuously the time and money required to heat this material is out of all proportion to the benefits obtained. Instances are very rare where more than a small portion of the stone particles are ice-coated and the heat of the mixing water alone is enough to thaw any such ice-coating before the concrete leaves the mixer.

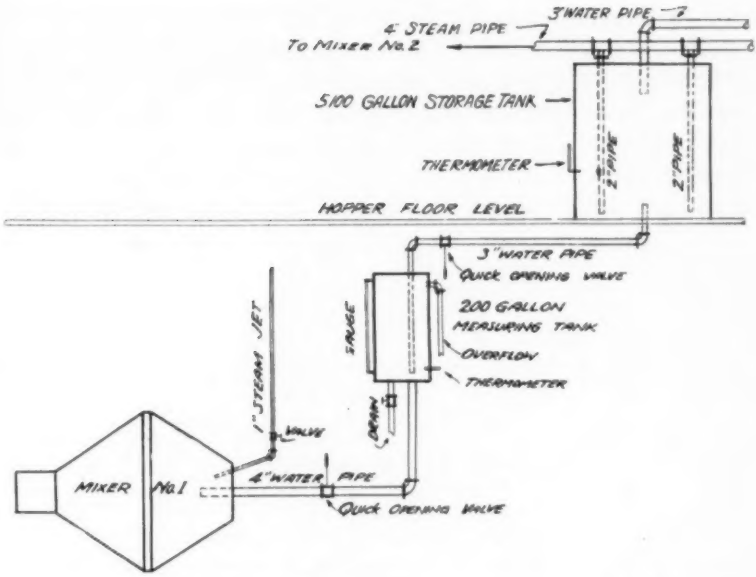


FIG. 7—ARRANGEMENT FOR SUPPLYING STEAM AND HOT WATER TO MIXERS

By using live steam it is a simple matter to heat sand to almost any temperature from 60° to 150°. On our work the sand temperature usually runs between 70° and 80°—with the mixing water at from 180° to 200°. This combination, together with a 1-in. steam jet in the mixer, will produce concrete at from 70° to 100°.

Mr. Johnson recommends that the sand and stone be heated when the air temperature is 35° F. and lower. This precaution would certainly provide a comfortable margin of safety. However, the authors are of the opinion that in some cases it would add an unnecessary item to the cost of winter construction. Where the efficiency of the form protection scheme is questionable it might be a worthwhile precaution to heat the aggregates as Mr. Johnson suggests. It has been the experience of the authors that heating the mixing water only, will provide ample protection until the air temperature gets down to about 15° above zero.

The method used at Chute a Caron for supplying hot water and steam to the mixing plant may be best understood by study-

ing the diagram, Fig. 7. The 4-in. pipe-line, which supplies the steam for heating water in the two 5100-gal. storage tanks, is taken from two 80-h. p. boilers. These boilers also furnish steam for the 1-in. jets in the mixer drums and for the various jets in the sand stock-pile.

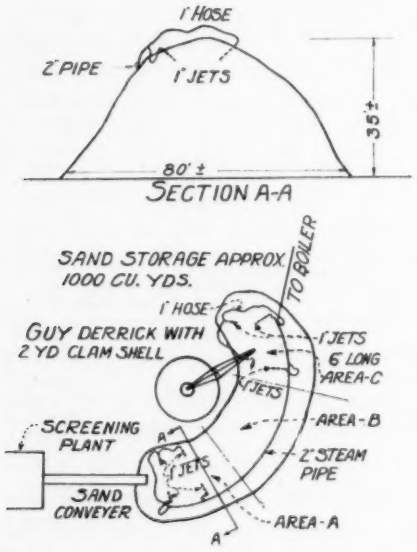


FIG. 8—METHOD OF HEATING SAND IN STORAGE PILE

The sand in the storage pile is heated by several 1-in. steam jets which are moved about as conditions require. The storage pile is divided roughly into three areas, two of which are being steamed while sand is being used from the third. A sketch showing the sand heating arrangement is shown in Fig. 8.

If conditions do not favor the storage pile arrangement, and it is found more convenient to deliver sand directly from the pit to mixing plant bins, a very satisfactory method of heating is to provide steam jets in the dump cars, as shown in Fig. 9. Eight 1-in. steam jets placed in a 30-yd. car will thaw all frozen lumps and heat the sand to about 100° F. in about 3-hours. If the sand

is to be screened before using, an added benefit of heating in the cars lies in the fact that the hot sand prevents the conveyor belts and screens from freezing. The maximum loss of heat caused by handling sand from cars, through the screening plant and into the mixer bins, was found to be about 20 degrees.

While the heating and protection arrangements outlined above have given very satisfactory results at Chute a Caron Dam, there

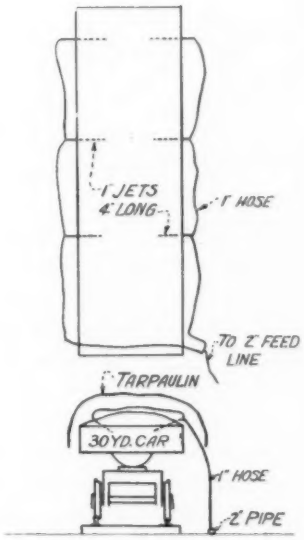


FIG. 9—METHOD OF HEATING SAND IN DUMP CARS

are doubtless many other methods in use which are just as good, or better. It would be a fortunate circumstance if Mr. Johnson's committee could be successful in getting all engineers who are familiar with cold weather concreting work to record their experience in order that the most efficient methods could be described in detail and published in his committee's final report. If "Recommended Practice for Winter Concreting" is to be written and sponsored by the Institute, the economic phase should be given very careful consideration. While the ultimate

aim of such a specification should of course be to produce concrete of the quality prescribed by the design, the requirements of the specification should be such as to avoid unnecessary expense. A constructor should not be required to keep a section of his concrete work covered and heated for 10 days if 3-days will suffice—neither should he be required to go to the expense of heating aggregates before conditions warrant such action.

Discussion of Report of Committee 403

"The Treatment of Monolithic Concrete Surfaces"*

BY H. M. HADLEY†

The report of Committee 403, Monolithic Concrete Surfaces, by N. C. Johnson, is good reading. Definite ideas are definitely expressed. There is nothing vague or nebulous about Mr. Johnson's statements, and whether in agreement or disagreement with them, one finds them refreshingly explicit and to the point.

Mr. Johnson looks for major developments in concrete as a surfacing material of artistic worth by removal of "the objectionable and harmful cement form skin" and exposure of the aggregate, either without further treatment or as a clean sound base for veneers. He properly enumerates the several defects and disadvantages which may singly, or severally, or—also be it said—may not at all occur with form-cast surfaces. "The constant and resistless and never-ending action and reaction of this surface excess of cement with atmospheric moisture" does indeed lead to "unfortunate volumetric and appearance changes" sometimes and under certain conditions, but such changes are not inevitable. In fact, the writer's observations, not wholly confined to "balmy climates of almost constant humidity," would lead him to think that concrete surfaces, untouched and direct from the form boards, withstood the attrition of weathering processes in a highly satisfactory manner wherever the concrete itself was of sound, good quality. Where the quality was not good, that fact also was revealed. It is impossible to run a bluff on nature. But

*By N. C. Johnson, author-chairman; Journal, May 1930—A. C. I. *Proceedings*, Vol. 26, p. 717.

†Regional Structural Engineer, Pacific Coast Region, Portland Cement Association, Seattle, Washington

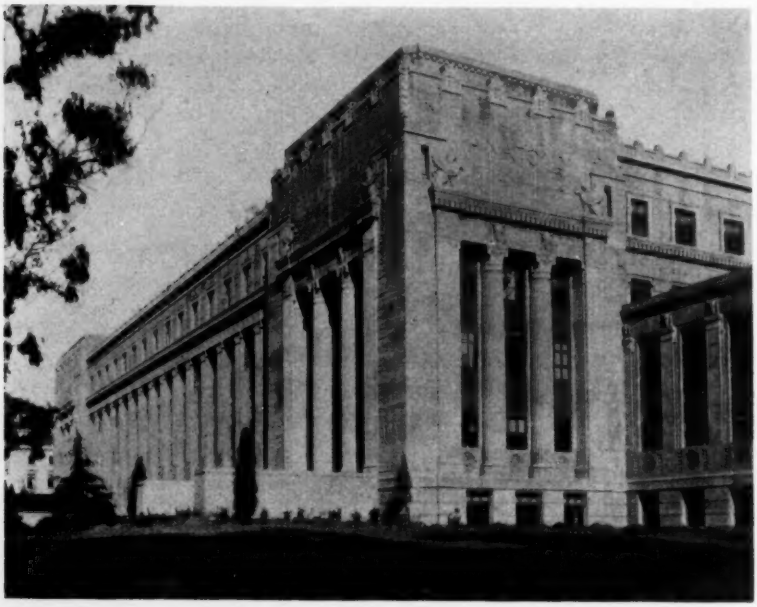


FIG. 1—LIFE SCIENCE BUILDING, UNIVERSITY OF CALIFORNIA, BERKELEY. GEORGE W. KELHAM, ARCHITECT. ENTIRE STRUCTURE OF MONOLITHIC CONCRETE, INCLUDING ORNAMENT

the opinion is submitted that concrete of good structure and quality possesses a form-cast surface requiring no additional treatment to render it enduring and permanent, and, in this respect at least, entirely satisfactory.

It is because the great and truly impressive growth of architectural concrete on the Pacific Coast has proceeded almost wholly through the development of the form-cast surface that fuller mention of such treatments should be made. These form-cast surfaces have been wash-coated, acid-stained, or painted for color as the case may be, or may have been left in natural color, but they are all characterized by the distinct preservation of the form marks and form surfaces. Such architectural designs emphasize *concrete*, in contrast with designs in which veneers,

either of mortar or masonry, conceal it. They present construction problems, some of a general and some of a peculiar nature, but they also offer opportunities for the exercise of freedom in architectural design which is delightful and the beauties of whose results cannot but command admiration and respect.*

He was a brave man who ate the first oyster, it is said. Quite his peer is that nameless architect who first dared to leave concrete frankly exposed, with the form-marks showing and the grain of the wood revealed and imperfections of various minor kinds all plain to view. Here a board bulged slightly; there was a knot; over there a nail bent for some cause or other and a carpenter swore. But the nameless architect who knew that according to all the conventions it ought to be plastered or

*See "Architectural Concrete—Forms, Molds and Surfaces" by William C. Wagner, in the pages of this JOURNAL issue.—EDITOR.

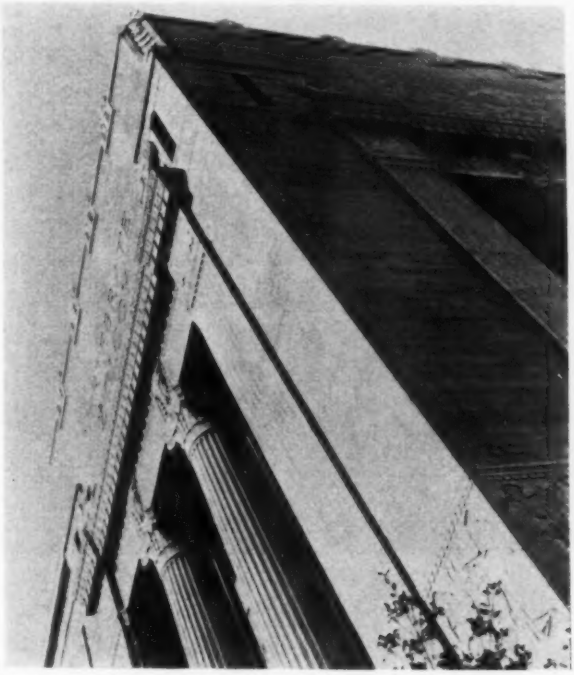


FIG. 2—DETAIL OF LIFE SCIENCE BUILDING, SHOWN IN FIG. 1

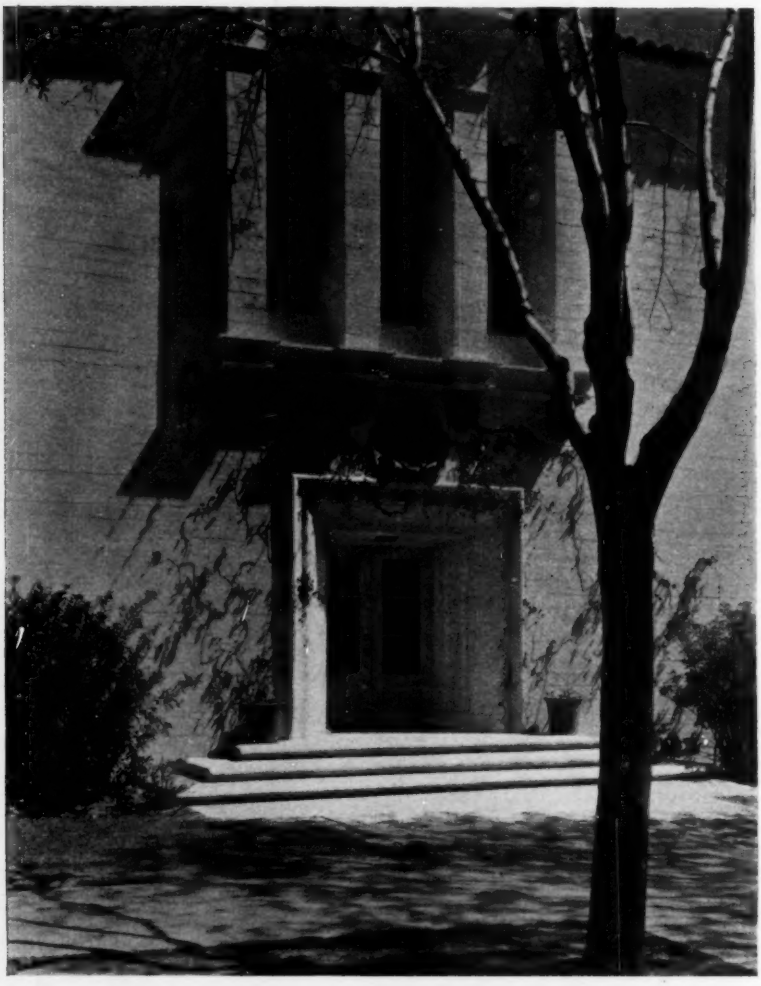


FIG. 3—ENTRANCE HAWTHORNE SCHOOL, BEVERLY HILLS, CALIFORNIA. R. C. FLEWELLING, ARCHITECT

veneered, also knew in his own mind that this surface with natural random variation of line and texture, just as it came from the forms, was rich in interest and was as good as any veneer could possibly make it. Why not, when the forms and molds are as characteristic of concrete, are as intimately and as essentially part of the construction, as is the concrete itself? It is basically good in everything, architecture included, to be honest. So since the cost of the veneer he had planned on could be used to take care of one or two troublesome "extras" that had developed on the job, and since he had pretty good concrete in the walls anyway, our nameless architect nerved himself and decided to leave it exposed with only a wash coat to give it color. And he got away with it, and later found that he liked it more and more, and found that after the first shock, other people did, too; and so on.

Probably such are the details of this first and unknown case. Be they what they may, the later uses are known and stand in evidence, and of their beauty and charm there can be no question. They are accomplished facts. See Figs. 1, 2 and 3. For buildings of more formal character to which the ordinary textures of wood are less well adapted, extremely true plane surfaces are obtainable by lining the wooden forms with sheets of pressed wood fiber. Jointing and rustication of such surfaces is obtained by nailing beveled strips over the fiber board lining. Again, various formal surfaces of large area may be obtained with wooden forms, milled to desired pattern, shellacked and oiled. For more elaborate decorative effects, waste molds of plaster, or wooden molds, are built in with the wooden forms and offer wide scope for variety in design. Accompanying views are representative of the results being obtained with treatments of this type.

Color effects may be produced in this type of construction where other than the natural tone of the cement is desired either by wash coats or by the integral admixture of color in the cement. The Wilshire Professional Building derives its white color from a paint coat. The exposed concrete of the Richfield Oil Building—approximately half of the entire exterior—was made to conform with the black terra-cotta of the main facades by covering it with a China wood-oil carrying a carbon pigment.

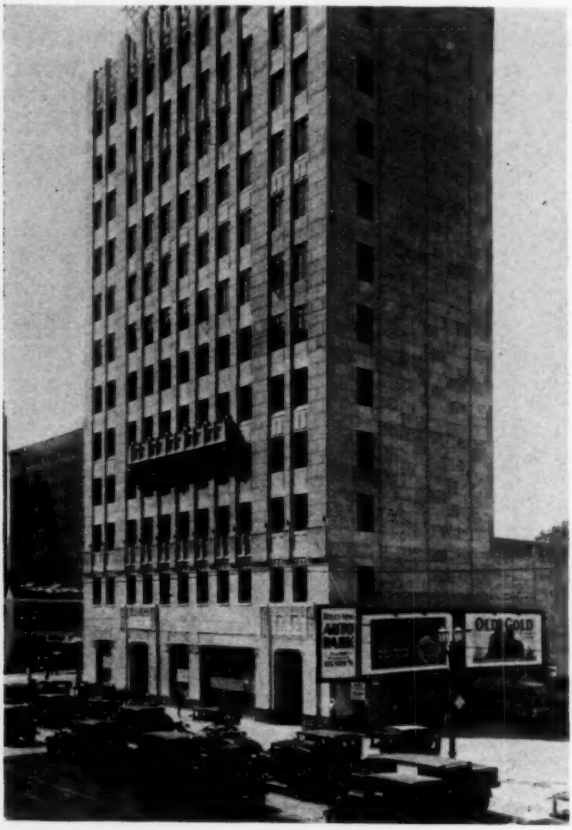


FIG. 4—BANK OF HOLLYWOOD BUILDING. TWO LOWER STORIES ON STREET FRONT ARE TERRA COTTA; ABOVE, ALL CONCRETE WITH SURFACES AS LEFT BY PRESSED FIBRE FORM LINING AND ACID STAINING BY LAEMMENS PROCESS

It cannot be too strongly emphasized that with designs contemplating exposed concrete exteriors, the concrete, just as the name indicates, is really and actually to be exposed in the finished structure and will be in the plain sight and view of everyone. This means that comfortable, easy-going, good-enough concrete, whose defects can so easily be concealed by veneers, is eliminated at the outset. It simply cannot be tolerated because it would be an

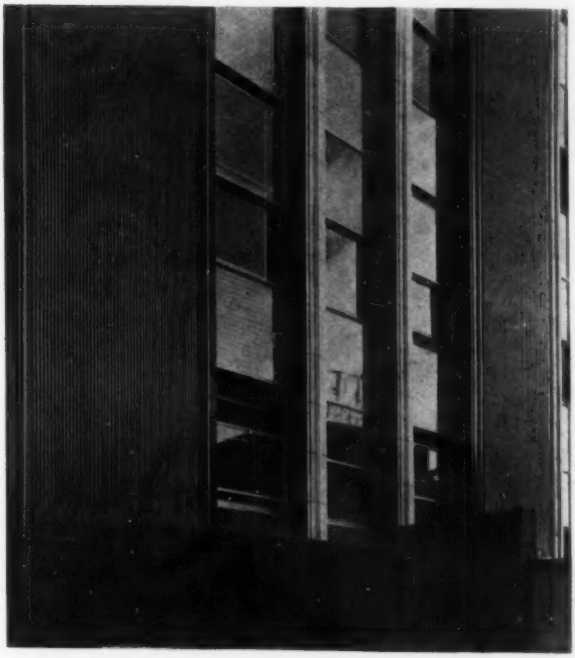


FIG. 5—DETAIL OF CONCRETE PORTION OF RICHFIELD OIL BUILDING, LOS ANGELES. TERRA COTTA ON STREET FRONTS; CONCRETE ON PROPERTY LINE SIDES; WOOD FORMS WERE MILLED AND FLUTED TO CONFORM WITH TERRA COTTA

eyesore to all beholders and a continued standing indictment of the contractor who built it and of the architect who permitted it to be built. It would be better not to attempt exposed concrete than to fail at it. Yet successful results can be obtained readily. What is required is a concrete surface of uniform quality, free from gravelly, honeycombed blotches, segregation of materials, ragged and irregular pour lines, laitance or sawdust in construction joints, badly sprung forms—in fact a concrete free from major and serious defects. There must be obtained as near to a full 100 per cent extent as possible that same excellent good quality of concrete surface which even a poor job will show over

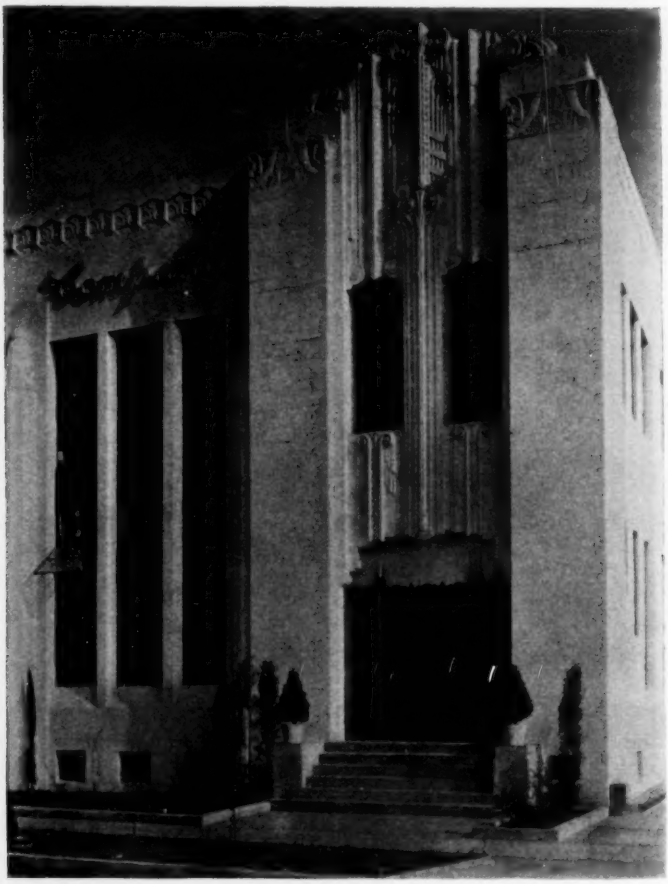


FIG. 6—HOFFMAN CANDY CO. BUILDING, LOS ANGELES. PLASTER WASTE MOLDS USED TO PRODUCE ORNAMENTATION

most of its area. A plastic workable mixture of minimum water content has to be placed to fill completely the forms which have been built to receive it and in such a manner as to result in a homogeneous, uniform concrete. Merely superficial blemishes—air pockets, water voids, exposure of fine honeycombing of no depth —are not at issue. They give variety and attractiveness and interest and prevent the monotony of uniform perfection. But

the question of uniform, good concrete is of issue and has to be met.

The architectural uses of concrete are to be welcomed by everyone concerned with improving the quality of concrete. To bring concrete into the focus of attention, to make it visible, subject to the critical examination of all eyes, will almost automatically eliminate careless slipshod work. When slipshod work can not be hidden but has to stand in plain view, nobody wants it and everybody disclaims it. It becomes inexcusable, intolerable. To subject concrete to such a searching scrutiny and inspection as it must of necessity receive when used architecturally will have a very wholesome effect upon its quality.

BY B. STUART MCKENZIE*

IN MY construction experience I became acquainted with two methods of finishing concrete surfaces which have not been mentioned. Both methods proved most satisfactory in service.

The first consisted in the application of a cement grout wash rubbed in by means of a canvas sack, usually an old cement bag, immediately after the removal of the forms. The result was much more satisfactory than that obtained by the use of a whitewash brush, which is the usual custom.

The other method consisted in the use of a hand block made of cement mortar. The surface to be treated was thoroughly wet with a whitewash brush and then rubbed with the cement block. This served to grind off the surface imperfections and also to fill voids and produced a surface which was practically perfect.

It may be objected that these methods, particularly the latter method, are too expensive from an operating standpoint but in my own experience the results obtained were well worth the cost.

AUTHOR'S CLOSURE BY NATHAN C. JOHNSON

DISCUSSION of any subject is always most interesting. The discussion by Mr. McKenzie and Mr. Hadley are welcome sidelights on this subject of surfacing, which has too long been neglected.

The writer intended, in speaking of "Wash and Float Finishes," to include by inference the methods mentioned by Mr. McKenzie.

*Secretary, Canadian Engineering Standards Association.

Beyond this acknowledgment, there seems no need to amend the text of the report as it is.

The comment of Mr. Hadley is particularly forceful in one sentence.

This sentence is: "It is impossible to run a bluff on Nature."

This sentence, perforce, runs through all of Mr. Hadley's comment. Each paragraph of that comment should have, as an opening sentence, this deep truth, that: "It is impossible to run a bluff on Nature."

Mr. Hadley brings California to us once again, but all the concrete in the world is not in Los Angeles. For every photo he will show in illustration of his comment, any camera in any other clime or city could bring other photos, sometimes unbeautiful in the extreme, proving by concrete buildings elsewhere, that "It is impossible to run a bluff on Nature."

It is recognized that Mr. Hadley's comment is familiar propaganda. But is it helpful propaganda? Unless a statement of position tends to advance or improve an art, over what has been done before in that art, it may well prove to be harmful and delusive.

In Egypt, thousands and thousands of years ago, long before portland cement was thought of, the artisans of that country colored, stained, painted and otherwise over-treated mud surfaces (form surfaces, if the term is preferred) because they were unlovely as they were and because it was even then recognized that they had to be and should be covered up to make them "good enough," even for those days.

And they succeeded then, because the climate of Egypt is so ridiculously dry that even unbaked mud bricks of those past ages have endured to the present day.

In Los Angeles, where humidity is so constant, one can and may cover up unlovely form skins with stains, varnishes, china-wood paints and other means as mentioned. But to infer or to state that in other and unlike parts of the world these things may be successfully done, is no kindness to the art of using concrete, for "It is impossible to run a bluff on Nature."

In detail, one cannot but wonder if Mr. Hadley ever attempted to make or to cast an intricate form, or to line a form with pressed wood fiber and so on. Some of us have.

It is also a grave mistake to talk, except perhaps in California, of painting concrete with china-wood or linseed paints, without special pre-treatment.

Other comments on the factual and economic aspects of Mr. Hadley's views might properly be made and to the advantage of the industry, but if it be remembered in reading them, that it is, in very truth, "impossible to run a bluff on Nature," much time will be saved.

The Committee report as it stands, it is true, mentions things that our grandfathers did not know about, although they knew all about form-mark surfaces. But in no industry that we know of is enterprise and improvement considered a crime, except in the minds of the few and even with them, it is a crime for a brief time only.

As Dr. Aggasiz so aptly phrased it many years ago:

> Every advance passes through three stages: First, men say it is not true. Then, they declare it is hostile to accepted beliefs. Finally, they say that it is right and is true and that everyone had always known it.

The Committee report as it stands does not seem to need correction or modification.

ABSTRACTS

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of the current literature of cement and concrete

PREPARED UNDER THE DIRECTION OF THE
AMERICAN CONCRETE INSTITUTE
COMMITTEE ON ABSTRACTS

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MATERIALS

ADMIXTURES

American experiments and experiences with Tricosal. A. KLEINLOGEL. *Zement* (Germany), Aug., 1930, V. 19, No. 32, p. 758-60.—Properties of Tricosal were carefully examined and it was found that water addition for making of concrete can be lowered about 10 per cent when 1 per cent Tricosal is added. Compressive strength was increased 18 per cent with 1 per cent Tricosal while tensile strength was raised about 43 per cent. Additions of Tricosal improve impermeability of concrete. Briquets were broken and cemented together with Tricosal. After 48 hour storage in moist closet briquets were broken again and all showed new breaks at different places.—A. E. BEITLICH

Waterproofing of concrete structures. (See FIELD CONSTRUCTION—Miscellaneous.)

Lactic acid, mortars and brick floors. (See PROPERTIES OF CONCRETE.)

AGGREGATES

New sand and gravel operation in Philadelphia territory. *Rock Products*, May 10, 1930, V. 33, No. 10, p. 49-53.—Log washers and special types of screens are used to make concrete aggregate from bank material that contains considerable quantities of clay which had hitherto been found difficult to remove. Operation of machines is described in detail with flow sheets and quantities.—EDMUND SHAW

Brick and stucco mortars. K. A. GOSLICH. *Tonind. Ztg.* (Germany), 1930, V. 54, p. 1079-83.—Author thinks that the sand should have sharp corners. After reviewing literature on effect of clay and loam, he points out value of clay in small amounts in filling voids, but states organic matter of humic type must be absent. For stucco the sand must be finer than for brick laying. Also for stucco it has been found (in Germany) that sand containing original moisture makes stronger mortar than if it is allowed to dry out.—F. O. ANDEREGG

Selection and acceptance of sand and gravel for concrete, especially reinforced concrete. OTTO GRAF. *Tonind. Ztg.* (Germany), 1930, V. 54, No. 71, p. 1159-60; No. 72, p. 1175-7; No. 74, p. 1203-5.—After the specifications of concrete are determined, careful selection of materials is needed to meet the specifications safely without running too far over. Quality of cement should be uniform. Aggregate should be fairly uniform in grading and to secure this result, sand and gravel should be separated by a ¼-in. screen (7 mm. holes). Gravel should not run much larger than 1¼ in. (30 mm. holes) and should be nearly free from flats. Effect of grading of sand on density, strength resistance to corrosion, etc., of the concrete has been studied and best results are obtained with Fuller curve grading, except that a little more fine material increases resistance to corrosion. Grading recommended is consistent with German and American specifications and is approached by many commercial aggregates.—F. O. ANDEREGG

Tentative specifications for light weight cast stone (Schwemmsteine) from Bims aggregate. German Standards Committee. *Tonind. Ztg.* (Germany), 1930, V. 54, No. 69, p. 1133.—Bims aggregate is a porous pumice stone which is cast into blocks with lime, standard cement or special cements as binder. The standard shape is 4 x 5 x 10 in., but others are allowed. The maximum weight for this size is 5.34 lb. For compressive strength the flat sides are made parallel with mortar and the air-dry strengths on 10 stones must average 170 lb. per sq. in. when lime is used as the binder, 286

with standard cements and 419 with special cements. The stones must withstand 25 cycles of freezing to 25°F. when saturated with water followed by thawing. These stones have been recognized as fire resistant by the Prussian Ministry for the Peoples Welfare (Voklswohlfahrt). The sp. heat conductivity should range from 2.5 to 3.1 B. T. U. per hr., per sq. ft., per in., per deg. F. difference.—F. O. ANDEREGG

Effect of addition of finer sizes to gravel on strength of concrete. STANTON WALKER. *National Sand Gravel Bul.*, August, 1930, V. 11, No. 8, p. 5-11.—An investigation of strength of concrete, coarse aggregate for which contained varying amounts of finer sizes of gravel, has been carried out in the research laboratory of the National Sand and Gravel Association. This report gives detailed results of tests and some studies of them. Gravel deposits, because of method by which they were formed, often contain an excess of certain sizes which are limited by specifications based on use of arbitrary proportions. Common size to occur in excessive amounts is that generally known to industry as "pea" gravel. Elimination of these sizes often constitutes an economic waste which could be avoided by proper design of the concrete. Ten different gradings of gravel were used, the differences being in amount of No. 8 to No. 4 and No. 4 to ⅜ in. sizes added to a ⅜ to 1½ in. gravel. The tests were divided into two groups. First consisted of studies of 10 gravel gradings in four concrete mixtures as follows: 1-1½-4½, 1-2-4, 1-2½-3½ and 1-3-3. In second group one grading of gravel was tested in mixtures ranging from 1-1-2 to 1-3-6, each containing sand and gravel in proportions of 1 to 2. Compression tests of 6 by 12-in. concrete cylinders and transverse tests of 6 by 6 by 30-in. beams were made. In the concluding remarks the following statements are made: (1) For standard method of molding specimens used in this investigation, it is apparent that 1-1½-4½ mix contained insufficient sand to provide proper workability. (2) Reductions in strength on account of inclusion in ⅜-in. to 1½-in. gravel of relatively large quantities of material between ⅜-in. and No. 8 sieve were comparatively small. Inclusion of 30 per cent of No. 4 to ⅜ in. size decreased strength less than 10 per cent when comparisons were made for same arbitrary proportions. If quantity of sand in mixture is reduced to compensate for increased amount of finer material in the gravel and differences in cement content taken into account, strength is increased in some cases and in other cases reduction is small. (3) In general, reduction in strength on account of the addition of finer sizes was in proportion to additional quantity of mixing water, expressed as a ratio to volume of cement, required to maintain same workability. (4) Both compression and transverse tests in this investigation showed definite relationship between strength and quantity of mixing water, expressed as ratio to volume of cement, and indicated that mixing water was most important factor in controlling strength of concrete. (5) These data indicate that considerable economies may be effected by utilization of finer sizes of gravel.—C. E. PROUDLEY

Aggregate for Boulder Dam. (See FIELD CONSTRUCTION—Dams.)

CEMENT

Determination of sucrose soluble CaO in portland cement. T. F. SEDGWICK. *Rock Products*, May 24, 1930, V. 33, No. 11, p. 81.—Author, an industrial chemist of Honolulu, T. H., states he has found that method of determining sucrose soluble CaO in burnt and hydrated lime appears to give a fair index of the free lime in portland cement. He quotes standard methods for finding sucrose soluble CaO.—EDMUND SHAW

Wage rates and labor conditions in the cement industry in Europe. FRANCIS MILTOUN. *Pit and Quarry*, April 23, 1930, V. 20, No. 2, p. 37-55.—

Economic discussion, by an American who resides in Europe, of the protection given by European countries to their respective cement industries. Wage scales, productions and exports are covered for Sweden, Germany, Belgium, Denmark, France and Italy.—A. J. HOSKIN

The cement industry in Bologna. ANGELO LILI. Reprint from *Il Comune Di Bologna* (Italy), March, 1930, 4 p.—A general description of investigations made in Bologna, which have resulted in conclusion that it is logical location for cement mill. Previously unknown deposits of pure limestone were located and tests show that either natural or artificial cements can be economically produced. National legislation to stimulate construction and thus provide an outlet for production of cement mills in the country is recommended.—C. G. CLAIR AND M. N. CLAIR

A new theory for the fine grinding of cement. O. RAULIN. *Ciment* (France), 1930, V. 35, No. 9, p. 342. Cement may be ground too fine to give best results, the explanation given, being that the air cushion on very tiny particles prevents them from being hydrated. Each cement has a critical grain size which depends upon the burning and which gives the best reaction with water. This critical size should be determined for each cement and then adhered to.—F. O. ANDEREGG

Improvements in cement mill practice. A. B. HELBIG. *Zement* (Germany), Aug. 21, 1930, V. 19, No. 34, p. 796-9.—Author emphasizes importance of installation of air separator in cement grinding mill. Different types of separators are characterized, their advantages described and calculations of their power consumption given. (cf. A. B. Helbig, *Zement* (Germany), Jan., 1930, V. 19, No. 2, p. 25-8 and March, 1930, V. 19, No. 11, p. 237-9.)—A. E. BEITLICH

Practical guide for chemists in the cement industry. "Guide practique du chimiste dans l'industrie du ciment." C. TSOUNTAS. 1929, Editor: *Revue des Materiaux de Construction*, Paris (France), Fr. 20.00. Reviewed in *Zement* (Germany), Aug., 1930, V. 19, No. 32, p. 760.—Book describes analysis of cement, raw materials, fuels, gases, lubricants and water. No consideration is given to physical examination of finished cement. Laboratory test is described which consists of determinations of insoluble residue of ignited raw mix after certain time intervals. It is claimed that results obtained throw light on behavior of clinker in kiln.—A. E. BEITLICH

Burning of lime and cement. J. DEFORGE. *Rev. Materiaux Construction Trav. Publics* (France), 1930, No. 249, p. 212-6; No. 250, p. 262-6; No. 251, p. 298-303.—In the vertical kiln one difficulty is to get the gases properly distributed. One way to improve this is to introduce part of air admitted for combustion through a central chimney. Another kiln is described where producer gas used for fuel is admitted about ⅓ of the way up. Combustion air comes up through the hot lime. The top is closed and the gases are pumped out, being about 40 per cent CO_2 with very little CO, as compared with most shaft kilns where usually relatively large amounts of CO mean waste heat. The CO_2 is purified, cooled and condensed to a liquid; or it may be used in precipitating chalk or for other similar purposes.—F. O. ANDEREGG

Slurry filtration in manufacture of cement. GUSTAV BOEHM AND DESIDER STEINER. *Zement* (Germany), Aug., 1930, V. 19, No. 33, p. 768-75.—Directions for installation and operation of slurry filters in wet process cement plants are discussed. Heat calculations illustrating economy of process are given and tables show relations between water content and specific gravity of slurry. Preliminary tests must be carried out to find suitability of slurry for

filtering process. Slurry which tends to sedimentation is usually well suited for filtration while that which stays in suspension very long is hard to filter. Great uniformity of lime content as well as fineness of slurry is necessary. High temperatures have favorable effect; during winter slurry should be preheated and special care taken to prevent blocking of filters and slurry pipe lines. Continuous stirrers and cleaning every two weeks are suggested. Several different kinds of filters are discussed and their power consumption given. Engineering tests which were made to compare economy of wet process with filter method showed great superiority of the latter.—A. E. BEITLICH

Concrete of great soundness made up of portland cement and arsenious oxide. DONOVAN WERNER AND STIG GIERTZ. *Teknish Tidskrift* (Sweden), April, 1930, No. 5, p. 41-49.—The Royal Engineering Academy of Sweden has for one year carried on tests with a mixture of portland cement and As_2O_3, to find some use for As_2O_3 obtained as a by-product in production of iron in Sweden. This kind of cement is recommended for water resistant concrete, sewer concrete, etc. It was found that setting time could be controlled by heating the mixture. Best result was obtained with a mixture of 70 per cent cement and 30 per cent As_2O_3. For temperatures between 320° and 374° F., setting time was 1 to 3 hours. Higher temperatures delayed the setting. Strength was found greatest for the 30 per cent mixture. Compressive strength of mixture at 7 days was 3890 lb. per sq. in. compared with 2720 lb. for neat cement. After 3 months the corresponding values for the mixtures were found to be 5760 and 7920 lb. per sq. in., respectively. The soundness of the 30 per cent mixture proved to be very good. This mixture decreased the dissolving of CaO from .0507 for 100 per cent cement to .0045. Complete article includes 32 graphical tables.—O. ALBERT.

Is the regulation of the rotary kiln for uniform high efficiency made difficult by great variations of the silica modulus? OTTO FREY. *Zement* (Germany), Aug. 7, 1930, V. 19, No. 32, p. 744-5.—Experiments were carried out with raw materials, which showed great variations in silica content (silica modulus ranging from 2.2 to 7.0). Raw mixture was so proportioned, that modulus was between 3.0 and 3.5. No unfavorable effect during burning process could be noticed. Following observations were made: No ring formations took place when silica modulus was between 3.0 and 3.5; when modulus sank below 3.0, a ring was formed; clinker was black in color and very hard; cement produced was of high quality; sintering point of raw mixture was 1520° to 1530° C. and fuel consumption was 25-26 per cent. Kiln lining was made of Dynamidon bricks.—A. E. BEITLICH.

Breaking down of tricalcium silicate by heat. S. L. MEYERS. *Rock Products*, April 12, 1930, V. 33, No. 8, p. 78-79.—Author found increase of free lime after ignition of cement, the increase being greater with higher temperature and with longer time of heating. This is ascribed to breaking down of tricalcium silicate to dicalcium silicate by heat with consequent liberation of free lime. Experiments on 4 $CaO:Al_2O_3$, Fe_2O_3, 3 $CaO:Al_2O_3$, 2 $CaO:SiO_2$, and 3 $CaO:SiO_2$, all prepared with pure materials, showed that only 3 $CaO:SiO_2$ liberated free lime on ignition. In heating ordinary portland cements, as much as 11.28% of lime has been liberated corresponding to the breaking down of 45.98% of tricalcium silicate to dicalcium silicate. A slightly higher liberation of free lime was obtained with high early strength cement. Clinker or unground cement did not show this reversion with heat. Aged cement was found more susceptible to heat reversion than fresh cement.—EDMUND SHAW

Disturbing effects in portland cement and high alumina cement mixtures. HANS KUHL AND SETSUO IDETA. *Zement* (Germany), Aug. 21,

1930, V. 19, No. 34, p. 792-5.—Portland cement clinker was ground together with different amounts of calcium—alumina melts of different compositions, prepared by fusing mixtures of $CaCO_3$ and Al_2O_3 in oxy-acetylene flame. Composition of melts varied from 3:5 to 4:1 ($CaO:Al_2O_3$). Portland cement clinker and alumina melts were ground separately to fineness of 10 per cent residue on 175 mesh sieve and mixed in proper proportions with an addition of 3 per cent gypsum of same fineness. Following mixtures were prepared: portland cement: alumina melt, 90:10, 75:25, 60:40, 40:60, 25:75 and 10:90. Tensile strength after 1, 3 and 7 days water storage was determined by small-piece testing method proposed by Kuhl. Authors drew following conclusions: melts similar to high alumina cement decrease strength of portland cement after one day when 25 to 40 per cent is present. Alumina melts of composition $2CaO:2.5\ Al_2O_3$ have disturbing effect only when 60 to 75 per cent is mixed with portland cement. When ratio $CaO:Al_2O_3$ becomes greater than 2.5:1, melt has tendency to increase portland cement strength slightly. It is stated that reactions take place between calciumhydroxide, which is formed by hydration of portland cement, and aluminum hydroxide from alumina melt.—A. E. BEITLICH

Experience with slurry filters at the Osborn, Ohio, plant of the Southwestern Portland Cement Co. EARL C. HARSH. *Rock Products*, May 24, 1930, V. 33, No. 11, p. 51-54.—Filters are of the American continuous type. Improvements noted from their installation are: increased kiln capacity, decreased coal consumption, material increase in steam generated by waste heat boilers. Formation of mud rings in kilns has been obviated and clinkers are smaller and burning more uniform. Only one of two 9-disk filters installed has been found necessary. Each 12-ft. disk of 15 sectors has 200 sq. ft. filter area. Palm twill, 15 oz. fabric has given best results. Life was 25 days but by treatment has been increased to 40 days. Cycle uses 40 per cent of time for pickup, 40 per cent drying and 20 per cent discharging. A 28-in. vacuum is maintained by duplex pump and motor. 3 h. p. variable speed motor drives filter through specially designed speed reducer at one revolution in seven minutes. The filter cake goes to a pug mill and is mixed with dust collected by Cottrell precipitation plant. Raw material is ground to 92 per cent passing 200 mesh. Slurry has 35 per cent water which is reduced to 19 per cent by filtering, a removal of 180 lbs. water for each bbl. of cement made.—EDMUND SHAW

Studies on lime—alumina cement I. SHOICHIRO NAGAI. *Kogyo Kwagaku Zasshi* (*J. Soc. Chem. Ind.* (Japan), May, 1930, V. 33, Supplemental binding, No. 5, p. 167-9.—Raw materials which are suitable for manufacture of a lime—alumina cement in Japan were investigated. This kind of cement was proposed by Richard Grün (Tonindustrie Zeitung (Germany), 1924, V. 48, p. 247) and contains approximately 15 per cent silica, 50 per cent lime and 28.2 per cent alumina and ferric oxide. Following raw materials can be used: limestone, puzzolana, loam, colloidal earth and diaspore. Analysis and compositions of these materials are given. Raw mixtures were sintered or melted in electric resistance furnace at temperatures ranging from 1300° C. to 1380° C. Tables show chemical composition of these burns. Hydraulic properties of products obtained were studied by testing on compressive strength of 1:3 cement—sand mortar with small-piece testing method. Cements lose strength in water curing at 7 days with a further considerable decrease at 28 days, but show great increase in strength at 28 days combined curing. It is stated that $5CaO.3Al_2O_3$ or $CaO.Al_2O_3$ are main components in lime—alumina cement from which hydrated product $3CaO.Al_2O_3.3CasO_4.nH_2O$ is dissolved in water which fact decreases its strength. Further studies will cover dusting of heated products, decrease of strength in water curing and increase of strength in air hardening.—A. E. BEITLICH

Long aerial tramway carries limestone to cement mill in the Cascades. FRANCIS CHURCH LINCOLN. *Pit and Quarry*, April 23, 1930, V. 20, No. 2, p. 41-48.—This is a complete description of Superior Portland Cement Company's plant and quarry near Concrete, Wash. Company succeeded Washington Portland Cement Co., the oldest cement company in the state. Limestone occuring in steeply-dipping beds, of various colors and qualities is raw material for wet process. Recrushed stone is belt-conveyed to the loading bin of a double-rope aerial tramway, whence it is transported 6,671 ft. to cement plant at rate of 260 tons per hr. Clay is taken from pit in 5-ton trucks to storage pile at plant. Slurry is pumped to an agitator trough and distributed to tube mills. Six kilns have a combined capacity of 5,200 bbl. per day. Fuel is pulverized coal.—A. J. HOSKIN

Iron oxide vs. alumina as a fluxing agent in the manufacture of portland cement. KATSUZO KOYANAGI. *Rock Products*, May 10, 1930, V. 33, No. 10, p. 82-83.—Author comments on the work of Anton Blank (c. f. *Rock Products*, May, 1928,) with iron oxide and alumina as fluxes in cement. He reviews his own experiments, given in detail, which show that with cement made by Cichibu Cement Co., Tokio, Japan, increasing the Fe_2O_3 content does lessen coal consumption and give a higher tensile strength as Blank claims but it also gives a lower compressive strength. With very high Fe_2O_3 content both tensile and compressive strengths decrease and cement becomes unsound. He notes that Blank experimented with high alumina cement while he experimented with low alumina cement. He concludes that when cement is high in alumina and low in silica, iron oxide can be advantageously used as a fluxing agent, but when cement is low in alumina and high in silica it is better to increase the alumina content a little, leaving the iron oxide content constant. Many tables show results from which conclusions were drawn.—EDMUND SHAW

Analysis of waste gases of rotary cement kilns and their part in kiln control. ALTON J. BLANK. *Rock Products*, May 10, 1930, V. 33, No. 10, p. 58-60.—Comparative tests on the Akron and Orstat apparatus showed they agreed on the CO_2 content of waste kiln gases within 0.1 to 0.2 per cent. Oxygen contents by the Akron device were somewhat erroneous. Carbon monoxide in waste gases was shown by the blackening of silver foil placed under discharge water pipe of Akron device and kiln operators noted this in controlling kiln operation. The reasons for changes in the CO_2 record, such as variation in amount of feed and fuel and the CO_2 content of materials and air and moisture admitted, are listed. Theoretical tables and charts were prepared showing fuel oil consumption for varying percentages of free oxygen in kiln gases and for CO_2 content of kiln gases. These were checked with actual measurements of fuel oil burned and found to be more or less in agreement. Author shows how examination of record may avoid fuel losses.—EDMUND SHAW

Progress in cement research during year 1929. C. R. PLATZMANN. *Zement* (Germany), July 31 and September 4, 1930, V. 19, No. 31 and 36, p. 722-4, 843-7.—Author gives comprehensive bibliography on subjects of recent cement research. Considerable work was done to find favorable relation between chemical constituents, which were expressed by certain moduli, and formulas to obtain best possible cement composition. In close connection with this work were experiments to represent cement constitution and composition by means of graphs and curves. Reactions in kiln and rate of formation of calcium silicates and other clinker minerals were studied by several investigators. Mechanism of setting and hardening process and role of manganese in portland cement clinker were research problems. Synthesis and hydration of calcium aluminates, as well as conditions under which these aluminates form

and exist, were carefully studied. Effect of water soluble admixtures on setting and hardening process of portland cement and high alumina cement was examined. A number of articles deal with relation between fineness of cement and its strength and setting properties. Numerous new methods for chemical analysis and determination of particle size of cement were published. A small-piece testing method, which was developed by Hans Kuhl and modified by S. Nagai, was applied to scientific cement research. Change from normal to quick setting cement on account of heat was studied in various places. Cement specifications were subject of many changes in several countries and new standards were suggested. Relations between fineness and strength, type of storage and strength and between cement strength and concrete strength were investigated. Number of publications deal with investigations of influence of aggressive waters, salt solutions, acids, bases and organic substances on cement, mortar and concrete made of different kinds of cement and cement mixtures. Reactions, which take place when specimens are stored in above solutions, were carefully studied and conclusions on hardening process and durability were drawn. Improvements and new installations in modern cement plants are briefly discussed and several other miscellaneous research subjects mentioned. A total of 129 references are given.—A. E. BEITLICH

Closed circuit dry grinding improves quality of cement. *Rock Products*, April 26, 1930, V. 33, No. 9, p. 56-58.—Superior Portland Cement Co., Superior, Ohio, improved quality of cement and increased plant output 40 per cent by grinding in closed circuit with air separators. Plant is dry process using Bradley mills for preliminary grinding. Material is slag and limestone. After removal of iron by magnetic separator and grinding in Bradley mill material goes to four tube mills in closed circuit with air separators. Five were required before air separation was introduced and a 6-day week is enough to keep kilns supplied for 7-days. Air separators are 14 ft. diameter at top. The feed (tube mill discharge) contains 70 per cent of 200 mesh but much of it is sent back to the tubes. A heavy return has been found to increase grinding capacity and improve quality. Final product of air separators has 87 per cent through 200 mesh which is as good for burning as finer product. Burning is in five kilns. Clinker is coarsely ground in Bradley mill then in four tubes in closed circuit with two 16 ft. air separators. About 35 per cent of what is fed to separators is returned and 70 per cent of this passes 200 mesh. The final product is 95 per cent through 200 mesh. Power required is 35 h. p. for each 14 ft. and 40 h. p. for each 16 ft. air separator. Each tube is driven by a 175 h. p. motor. Output of plant is about 3250 bbl. per day.—EDMUND SHAW

Determination of heats of formation of silicates from their oxides. R. NACKEN. *Zement* (Germany), Aug. 28 and Sept. 4, 1930, V. 19, No. 35-36, p. 818-25, 847-9.—A method is described to determine heat of formation of meta- and ortho-silicates of alkali earth metals from oxides and silica. Heat of solution of silicates in mixtures of hydrochloric and hydrofluoric acid can be measured, and heat of formation can be calculated from obtained data. Reactions are carried out in calorimeter with water thermostat, which keeps outside temperature constant with an accuracy of 1:1000° C. Container is made of platinum and provided with shielded thermometer and stirrer. Specific heat of solvents was determined either by electrical method or by using heat of crystallization of an undercooled solution of salol. Heat of hydration of calcium hydroxide was determined very accurately. Silicates were prepared in electric furnace by heating exactly proportioned mixtures. Following substances were examined and their heat of formation determined: α-$CaSiO_3$ (pseudowollastonite), β-$CaSiO_3$ (wollastonite), δ-Ca_2SiO_4 (calcium ortho silicate), $SrSiO_3$, Sr_2SiO_4, $BaSiO_3$ and Ba_2SiO_4. Difficulties were encountered with barium compounds due to their insolubility, and it was necessary to use pure hydrofluoric

acid instead of a mixture of HCl and HF. Obtained results with barium were not very satisfactory. Attempts were made to study magnesium silicates but without success on account of very slow reaction. Lead silicates were dissolved in mixtures of nitric and hydrofluoric acid and their heat of formation was determined. Formulas for necessary calculations are given, and application of graphic method is described. Reactions which take place in clinker during its formation can be studied under use of above method. (cf. W. A. Roth, *Zement* (Germany), July, 1930, V. 19, No. 27, p. 628-30.)—A. E. BEITLICH

Modern tendencies in the manufacture of cement and inherent dangers. ANGELO LILI. Nomograph, Bologna (Italy), March, 1930, 5 p.—Some of attempts made since 1927 to change requirements of national law in Italy regarding cement strength and density have been toward increase in 28-day compressive strength requirement for "normal" mortar from 3980 lb. per sq. in. to 4960 lb. per sq. in. and a reduction in density limit from 3.00 to 2.90. It is cited that the better cements usually have density of about 3.18 and that only reason for going below 3.00 would be to permit dilution of cement by inert materials. Demand for high strengths at 28 days is difficult to meet by all manufacturers without the use of methods or materials that may be injurious to durability of cement. Best composition of cement with given raw materials is that which has just sufficient lime to combine with the silica and the iron and aluminum oxides. Any other composition will be likely in time for form unstable compounds. The cements of proper composition (hydraulic modulus not exceeding 2) show large increases from 7 to 365 days, and even with the tensile strengths, about 1/10 of the compressive strengths. High hydraulic modulus gives high early strengths, but relatively small increases between 7 and 28 days, and sometimes retrogression thereafter. Instability of volume and low tensile strength also occur with a high modulus. Author urges the State to make investigation covering all types of cements produced, and from that data to set up only important requirements. He states trend toward high strengths is absurd because the result is use of more steel, formation of more cracks, more chance of corrosion of steel, and much question as to durability of concrete. It is suggested that cements meet a requirement for "normal" mortar of 256 lb. per sq. in. in tension, and 2560 lb. per sq. in. in compression at 7 days, with appreciable increase at 28 days and beyond. Also that every bag of cement sold bear a diagram showing the normal strength—age curve for the cement, and name of manufacturer, addition of inert material to be prohibited. Specification based on the 7 day test is also proposed as follows:

$$N = \frac{f_7 \text{ (compressive strength of normal mortar at 7 days)}}{7},$$

28 day strength $= \frac{N}{a} \times 28$, 365 day strength $= \frac{N}{b} \times 365$, with suggestion that $a = 3$ and $b = 20$. Strength in tension at 7 and 28 days should be about 1/10 of the compressive strength. The advantages claimed for this specification are that this allows manufacturers to obtain best combination of raw materials and cements of highest value, for their conditions and provides a minimum strength requirement that will meet average demand, but which does not restrict production of higher strength cement.—C. G. CLAIR AND M. N. CLAIR

Blast furnace slag cements. A. O. PURDON. *Rev. materiaux construction trav. publics* (France), June, 1930, No. 249, p. 205.—American readers will find

definitions of: (a) "iron portland cement" (ciment portland de fer) as a mixture of a minimum of 70 per cent portland cement clinker with granulated blast furnace slag; (b) of "blast furnace slag cement" (ciment de haut fourneau) or "slag portland cement" (ciment portland de laitier) as mixtures as above containing lesser percentages of portland cement clinker. These are not to be confused with "slag cement" proper (ciment de laitier), a mixture of slaked lime and slag without addition of clinker. The article is a summary of test evidence showing that strength of blast furnace slag cements is equivalent to that of portland cement after a sufficiently long time interval. Clinkers of different origin were mixed in laboratory with various slags. The "ideal" proportions were computed making all of free lime in clinker become saturated by acid components (silica and alumina) of the slag. Uniform fineness was insured by grinding the two constituents separately before mixing. Tests show that "ideal" proportions are actually most advantageous. Admixtures of clinker exceeding this optimum (34.7 per cent) result in no further increase in strength, but act to reduce it. Commercial blast furnace slag cement was compared with standard portland and rapid-hardening portland cements, mostly of Belgian origin. The tests showed that, while during the first days slag cement lags considerably behind portland, at 3 mo. their strength values are very close and at 1 year almost identical. Tests at ages of 5 and 10 years are scheduled. Comparison is made with strength tests at 2 years of iron portland cement made in Germany by Tetmajer and Michaelis. The "iron portland" cements were recognized as equivalent in strength to standard portland in 1909 after a bitter struggle of 8 years. Objectors to "blast furnace slag" cements have emphasized the presence of calcium sulfate in slag with consequent danger of liberation of sulfuric acid. This acid, however, becomes immediately neutralized by lime continually formed during the setting and hardening of cement. Another argument relative to expansion of blast furnace slag cements is not confirmed by actual experience, these cements showing in a high degree the desired constancy of volume. According to Fritsch, the blast furnace slag cement shows remarkable resistance to saline waters, in which property it excels the standard portland cement. Finally, its low cost, due to the almost negligible cost of slag entering into mixture to extent of 70 per cent, makes it a most desirable product.—M. A. CORBIN

MISCELLANEOUS

A high-sensitivity absolute-humidity recorder. CRANDALL J. ROSECRANS. *Ind. Eng. Chem.*, Analytical Edition, V. 2, No. 2, p. 129-134.—An apparatus has been developed for measuring and recording the amount of water vapor in the air, which is suitable for recording humidities from zero up to saturation within a temperature range from 100° to about 200° C. This apparatus is based on measurement of the thermal conductivity of water vapor and air mixtures and is continuous reading.—ROY N. YOUNG

Tricalciumsilicate. RUDOLF BRILL. *Zement* (Germany), Aug., 1930, V. 19, No. 34, p. 796.—Tricalciumsilicate was prepared by fusion of mixture of CaO and SiO_2 in right proportions and keeping product at temperature of 1500° C. for 3¼ hours and following quenching. Comparison of its X-ray diagram was made with X-ray diagram of dicalciumsilicate and complete similarity was found. Author claims that tricalciumsilicate does not exist, and obtained product is only mixture of dicalciumsilicate and free lime.—A. E. BEITLICH

A stucco that did not harden. OTTO FRIZ. *Tonind Ztg.* (Germany), 1930, V. 54, No. 65, p. 1070-1.—A row of houses built of lightweight concrete block of pumice stone (Schwemmsteine) was covered with stucco, the first coat being a white lime mortar containing a little portland cement and applied to the well wetted walls. The second coat was a gray or dolomitic lime mortar.

Stuccoing was done in the fall and damp weather of late fall and early winter prevented the well soaked walls from drying so that the lime did not harden until a warm spell of weather in February permitted moisture to evaporate.—F. O. ANDEREGG

Contribution to the knowledge of ceramic properties of lime—alumina—silicates and refractory and high refractory materials. E. BERL AND FRITZ LOEBLEIN. *Forschungsarbeiten auf dem Gebiete des Ingenieurwesens* (Germany), 1930, No. 325, 28 pp.—Investigations were carried out to study softening and melting points of pure chemical melts and refractory bricks, composition of which falls in the system $CaO—SiO_2—Al_2O_3$. Special consideration was given to heat conductivity. Diagram is given showing relation between softening point and melting point and chemical composition. Graphs show compounds with like properties in three-component system. Mechanical strength depends very much on silica contents. Method is derived which allows determination of true heat number, which factor expresses heat conductivity.—A. E. BEITLICH

Types of minerals in artificial melts of $2CaO.SiO_2$, $3CaO.SiO_2$ and $8CaO.2SiO_2.Al_2O_3$. KATSUZO KOYANAGI. *Kogyo Kwagaku Zasshi* (*J. Soc. of Chem. Ind.* (Japan), May, 1930, V. 33, Supplemental binding, No. 5, p. 161.—Author prepared following melts: $2CaO.SiO_2$, $3CaO.SiO_2$ and $8CaO.2SiO_2.Al_2O_3$ from purest raw materials and studied their thin sections under microscope with polarized light. In all specimens an abundant amount of crystal needles with strong double refraction was found, especially in the $2CaO.SiO_2$ compound. Needles are believed to be dicalcium silicate. In $3CaO.SiO_2$ crystals were found with weak double refraction, corresponding with "alit." Free lime crystals were found under microscope in melts which showed great amount of free lime by glycerol method.—A. E. BEITLICH

Corrosion of Lead in Buildings. *Engineering* (England), April 11, 1930, p. 494.—Lead is usually resistant to corrosion since the surface exposed to moisture, oxygen and carbon dioxide is converted into a protective film of basic lead carbonate (mixture of lead carbonate and hydrate) but if CO_2 is lacking lead oxide is dissolved or if CO_2 is present in excess the oxide film is changed to soluble bicarbonate, and in either case corrosion results. Instances of failure have occurred caused by contact of lead with cement. Corrosive action of cements and mortars in presence of water, oxygen and carbon dioxide appears to depend upon their content of free lime, which absorbs carbon dioxide preventing formation of protective film of basic carbonate, and partly as a solvent exposing fresh surfaces for attack. Aluminous cements, containing no free lime show no progressive attack on lead. Old cement and mortar, the lime of which has been completely carbonated is also inert. Tin coatings offer greater resistance to attack than leads. To protect lead from corrosive action of cement of mortar, good practice is to provide a protective coating of bitumen.—G. M. WILLIAMS

Studies on fundamental synthesis of calcium aluminates and their hydration VI. SHOICHIRO NAGI AND RYUICHI NAITO. *Kogyo Kwagaku Zasshi* (J. Soc. *Chem. Ind.* (Japan), Jan., 1930, V. 33, Supplemental binding No. 1, p. 37-43.—Test data are given, which show rate of combination when mixture of $CaCO_3$ and Al_2O_3 in ratio of 3 CaO to 1 Al_2O_3 is heated. Comparisons are made with data obtained by preparation of $5CaO.3Al_2O_3$, $CaO.Al_2O_3$ and $3CaO.5Al_2O_3$, which were reported in previous article (*Kogyo Kwagaku Zasshi* (Japan), 1929, V. 32, p. 965). When a mixture with ratio 5CaO to $3Al_2O_3$ is heated, it tends to form $3CaO.Al_2O_3$ with increasing temperatures.—A. E. BEITLICH

The bauxite deposits of the Ariege. V. CHARRIN. *Genie civil* (France), Sept. 20, 1930, No. 12, p. 281.—Ariège bauxites are least accessible deposits,

being located in foothills of the Pyrenees. The stratum runs east and west and seems to be result of tremendous upheaval. The average width of workable stratum is about 3.4 miles. Its thickness varies from a few inches to from 20 to 25 ft. White, red and all intermediate shades are represented in this deposit. The analysis of red low-silica bauxite is: alumina, 62 to 65 per cent; silica, 6 to 7 per cent; iron oxide, 12 to 15 per cent. Low-alumina refractory bauxite has following analysis: alumina, 40 to 44 per cent; silica, 36 to 40 per cent; iron oxide, 1 to 3 per cent. The average run of bauxite has following quality: alumina, 50 to 55 per cent; silica, 15 to 18 per cent; iron oxide, 10 to 15 per cent.—M. A. CORBIN

Studies on fundamental synthesis of calcium aluminates and their hydration IV. SHOICHIRO NAGAI AND RYUICHI NAITO. *Kogyo Kwagaku Zasshi* (*J. Soc. Chem. Ind.* (Japan), May, 1930, V. 33, Supplemental binding, No. 5, p. 164-6.—Authors report further studies on three eutectic mixtures: (1) 47 per cent CaO:53 per cent Al_2O_3 which is eutectic between $5CaO.3Al_2O_3$ and $CaO.Al_2O_3$; (2) 2CaO:1 Al_2O_3 which is nearly equal to eutectic mixture of 50 per cent CaO:50 per cent Al_2O_3 and (3) 33.5 per cent CaO:66.5 per cent Al_2O_3 which is eutectic between $CaO.Al_2O_3$ and $3CaO.5Al_2O_3$. Temperatures are given at which combination of these compounds is completed. Compound $2CaO.Al_2O_3$, which was reported as pure aluminate is now believed to be mixture of $3CaO.Al_2O_3$ and $5CaO.3Al_2O_3$. Compressive strength was studied of obtained products by small-piece testing method proposed by authors. Further investigations of compounds: "alit," "celit" and "gehlenit" are under way.—A. E. BEITLICH

Action of salts, acids and organic substances on cement and concrete. RICHARD GRUN. *Zeitschr. angew. Chemie* (Germany), June 14, 1930, V. 43, No. 24, p. 496-500.—Investigations were carried out to study influence of solutions of different concentrations of acid salts, free acids and organic substances on setting time, compressive and tensile strengths of portland cement and blast furnace slag cement. Concentrated solutions of calcium chloride accelerate setting process, but with increasing dilution, setting time becomes longer for both cements. Ferric chloride, aluminum chloride and mixture of calcium chloride and aluminum chloride have similar effects. Barium chloride has little influence. Initial tensile strength is usually lowered, but will be normal at 28 days. Compressive strength is only lowered by concentrated solutions, while diluted solutions improve strength, especially after 28 days. Hydrochloric acid leads to shortest setting times with great evolution of heat. With concentrations of 1.1 and 1.8 per cent, tensile strength is lowered in most cases but compressive strength shows great increase. Organic substances slow up setting process and destroy nearly all strength properties. Hardened concrete test pieces of 1:3 cement—sand mixtures were stored in phosphoric acid and oxalic acid up to one year. Concentrations of phosphoric acids were 5, 10 and 15 per cent, oxalic acids 1 and 5 per cent. Both cements passed tests fairly well. No visible effect could be observed after six months storage in 5 per cent phosphoric acid. Strength decreases after this period. Stronger acids have destroying influence after short time. Oxalic acid shows in general no influence, 5 per cent concentration causing small decreases in strength. Normal strength was noted after one year. Several references are given.—A. E. BEITLICH

The Italian cement, lime and gypsum industries. (See MATERIALS—Cement.)

New dry paint for the concrete brick industry. (See SHOP MANUFACTURE.)

PROPERTIES OF CONCRETE

Remixing cement mortar—building research station. *Builder*

(England), Sept. 12, 1930, V. 139, No. 4571, p. 440.—Results of tests on retempering are given, and it is stated that although with portland cement it may be possible to regauge the mortar after a period up to four hours, with rapid hardening cement a definite loss of strength is indicated. Further if a wet mix were allowed to stand and evaporation of excess moisture resulted, a slight increase in strength for this reason alone, might be registered. The practice in general is not recommended.—JOHN E. ADAMS

New fundamental questions concerning concrete composition. Abram's aggregate modulus and Spindel's graphic concrete synthesis. OTTOKAR STERN. *Zeitschrift des oesterreichischen Ingenieur und Architekten Vereins* (Austria), Aug., 1930, V. 82, No. 31-32 and 33-34, p. 255-7, 269-72.—Discussion of theory of four-component system and its application for calculation of concrete mixtures is given. Relation is shown between w/c-ratio and amount of dry solid substances. Formulas are given for calculation of voids and solids. In order to obtain best concrete consistency certain mixing rules are suggested which connect Abram's modulus, w/c-ratio and compressive strength. Limits for possible cement mixtures are calculated and directions are given for making of charts for above graphic calculations.—A. E. BEITLICH

The failures of mortars and concrete. "Les defauts des mortiers et des betons." J. MALETTE (France), Francs 63.50. Reviewed in *Der Bauingenieur* (Germany), May 9, 1930, V. 11, No. 19, p. 342.—First part discusses limes and cements, their constitution, chemical composition, behavior in sea water and specifications. Second part describes aggregates, mortar and concrete and illustrates all facts, which influence their normal behavior. Effect of aggressive waters and chemical substances on concrete is characterized. Numerous tests and experiments made by author conclude book.—A. E. BEITLICH

Chemical composition of outer layers of cement mortars and concrete II. SHOICHIRO NAGAI AND K. JOSHIWAZA. *Kogyo Kwagaku Zasshi* (J. *Soc. Chem. Ind.* (Japan), Jan., 1930, V. 33, Supplemental binding, No. 1, p. 43-8.—Experiments were made with mixed 1:2 mortars and w/c ratios ranging from 50 to 70 per cent. It was found, that loss on ignition and amount of calcium carbonate in outer layer increase with increasing w/c ratio. Sulphuric acid content increases simultaneously. Similar results were obtained with neat cements.—A. E. BEITLICH

Bond strength and resistance of concrete to impact and wear compared to its strength in compression, flexure and tension. R. FERET. 1930, Published by *Rev. materiaux construction trav. publics*, Paris (France), 1 V., 72 p.—The author distinguishes two fundamental classes of strengths: compression and shear, proportional one to the other, and tension and flexure, equally proportional one to the other, but showing no fixed relation with respect to the former. Personal experiments and detailed study of data from other sources show that in a series of mortars or concretes made with the same cement and differing by one variable factor only, tensile (or flexural) strength increases less rapidly than compressive strength and varies approximately as the 2/3 power of the latter. In mixes of varying composition, the relation of the former to the latter strength is approximately proportional to that of quantities of water and cement. This discrepancy between the two classes of strengths depends to a large extent on the fact that composition near the surface of test specimen is rarely identical with that of the core, due partly to unequal distribution of materials against the walls of the mold, and partly to unequal hardening of the mass, the curing medium having a more direct effect on some parts of the specimen. Aside from this, strengths are variably in-

fluenced by latent stresses, varying according to the distance from the exposed surface, and produced by changes in volume as a result of chemical, thermic and hygroscopic action. It thus appears that tests of concrete in tension and flexure do not show adequately the stresses of similar nature which concrete will withstand on the job, while compression strength values are proportional to actual strengths. Resistance to shock and wear, as well as bond strength differ from the fundamental classes of strengths, but appear in certain series of concrete tests to be proportional to one or the other group. Resistance to wear by abrasion depends almost entirely on the hardness of the rock materials used in the concrete.—M. A. CORBIN

Lactic acid, mortars and brick floors. E. SUENSON. *Der Bautenschutz* (Germany), 1930, V. 1, No. 1, 2, 4 and 6, p. 3-6, 30-3, 59-63, 80-5.—Comprehensive investigation was undertaken to study influence of lactic acid on cement mortars. Acid was used in three different concentrations: 1/10, 2/10 and 3/10 normal with pH:2.4, 2.3 and 2.2. Following kinds of cements were tested: (1) portland cement, (2) portland cement with admixture of Ceresit, (3) portland cement with Sika 1, (4) portland cement with Sika 4a, (5) Danish Velo cement, (6) French Alzement (high alumina cement) and (7) American Medusa White cement. Test pieces made for study of volume changes in mixtures 1:2 and 1:4 were immersed in pure water, three lactic acid solutions of above concentrations, milk and butter milk. No considerable changes in volume were observed. Solutions showed different grades of aggressive action on cements. Effect of hot and cold water on volume of test pieces was investigated. Strength tests were carried out with 1:4 mortars with small slabs and cubes which were stored in lactic acid solutions. Compressive and flexural strength properties were studied. Lactic acid lowers compressive strength much more than flexural strength. None of the special cements or mixtures showed much better behavior than ordinary portland cement. Resistance to acid and relation between compressive and flexural strength increases very much with cement contents and coarseness of sand.—A. E. BEITLICH

Action of salts, acids and organic substances on cement concrete. (See MATERIALS—Miscellaneous.)

Corrosion of lead in buildings. (See MATERIALS—Miscellaneous.)

Concrete of great soundness made up of portland cement and arsenious oxide. (See MATERIALS—Cement.)

Effect of addition of finer sizes of gravel on strength of concrete. See MATERIALS—Aggregates.)

Light weight concretes. (See MATERIALS—Aggregates.)

Use of under-water concrete in Sweden. (See FIELD CONSTRUCTION—Miscellaneous.)

ENGINEERING DESIGN

BRIDGES

Handbook for reinforced concrete. III. "Handbuch fur Eisenbeton." W. GEHLER. 1930, Wilhelm Ernst und Sohn, Berlin (Germany), V. 4, new edition, R. M. 6.80. Reviewed in *Der Bauingenieur* (Germany), May 23, 1930, V. 11, No. 21, p. 373.—Subjects of book are calculations and construction methods of reinforced concrete bridges, construction of roadways, joints, abutments, piers and hinges. Several outstanding bridge structures are discussed.—A. E. BEITLICH

Queen Margaret bridge, Glasgow. *Concrete Constr. Eng.* (England),

Sept., 1930, V. 25, No. 9, p. 510.—The bridge is a simple parabolic arch, having a skew span of 137 ft. between abutments. Angle of skew is 26 degrees. A subway is arranged over each abutment for traffic along the river. Some difficulty was experienced in the design of one of the abutments, owing to the presence of a 5 ft. brick sewer, which followed the line of the abutment beam. Difficulty was overcome by providing reinforced concrete beams over the sewer so horizontal component of thrust was taken over top of sewer. Reinforced concrete was used exclusively for the structural work and parapets of bridge were of red granite.—J. MARIN

Stresses under the Freyssinet method of concrete-arch construction. J. T. THOMPSON. *Eng. News Record*, Aug. 21, 1930, V. 105, No. 8, p. 291.—The principal advantages and economics claimed for Freyssinet method of concrete-arch construction may be briefly summarized as follows: (1) Elastic rib shortening and shrinkage stresses may be practically eliminated, with reductions in rib sections. (2) By postponing the keying until temperature of air has reached a desirable mean value, temperature stresses may be considerably reduced. (3) Secondary stresses due to lateral deflection of abutments may be practically eliminated. (4) Continuity may be developed at ends of centers in long spans, thus reducing deflections. Centers are struck by exerting jack pressures that widen the opening at the crown a sufficient amount to lift the rib clear of the centering. Author presents data relative to stresses in typical Freyssinet concrete-arch bridges in France where method has been used extensively and points out that highest stresses may be reduced as much as 35 per cent.—D. E. LARSON

BUILDINGS

A large reinforced concrete aeroplane hangar. C. E. HOLLOWAY. *Struct. Eng.* (England), Sept., 1930, V. 8., No. 9, p. 317-328.—A design in reinforced concrete, submitted in open competition with steel, was chosen for an aeroplane hangar having a clear floor area of 80 by 100 ft. and built at Heston Air Park, Middlesex, England. The design is featured by r. c. tied arches of 100 ft. clear span and 20 ft. rise, spaced 16 ft. on centers, and mounted on lead sheets. Main columns are provided with side wind struts which slope away from the tops of columns at 45 degrees. Wall panels were cast into preformed grooves in sides of wall members, thereby confining cracks to the grooves. Office and shop space is provided on the sides of the structure beneath wind struts and additional office space was made overhead between walls and adjacent arches, floors for the suspended offices framing into the arch ties. Analysis and details are given for arch ribs, hangers, ties, columns and struts.—V. P. JENSEN

Concrete airship hangar of bold design at Sevilla, Spain. A. A. PETERS. *Eng. News Record*, Aug. 28, 1930, V. 105, No. 9, p. 324.—Huge arched-roof hangar of reinforced concrete in unusual and bold design is being built for airships of Zeppelin type at Sevilla, Spain. Designed to hold two large dirigibles, it is 950 ft. long, 400 ft. wide and 200 ft. high. Plans were based on those developed for small war-time steel structure planned for Italy. It was proposed to utilize a portion of old steel shipped to that country prior to signing of armistice. This plan proved to be futile and cost study indicated that arch design in reinforced concrete would be cheaper than modern structural steel building. Structural steel centering is being used for arches and quick-setting cement is being imported from England to cut down time limit on removal of supporting forms and speed up cycle of operations for each setup. Cement gun is being used to place concrete in wall of bays between arch ribs. These walls are only 4 in. thick and contain double lines of reinforcing bars.—D. E. LARSON

DAMS

Circular concrete arch dam designed by simple method. R. P. V. MARQUARDSEN. *Concrete*, Oct., 1930, V. 37, No. 4, p. 27-29.—Author outlines a method of calculating fibre stress in concrete of a fixed-end circular dam with a constant cross section in any horizontal plane. An elevation of the arch is drawn, a base line is established to permit proper application of the stress formula to the extrados and intrados sides of the various sections of the dam. The formula for fibre stress at any section involves water pressure, radius of curvature to both the center of the dam and the upstream face, thickness of dam or arch, coefficient of expansion or contraction, temperature changes, amount of settlement, modulus of elasticity of concrete, various angles including the central angle of the arch, and three sets of quantities which are functions of the central angle and which are given in three charts. Calculation of fibre stress for crown and end sections are very simple. Shearing stresses may be found by a simple formula submitted. Derivations of formulas given are to be published in November issue of Concrete.—N. H. ROY

MISCELLANEOUS

Nomogram for calculating slabs and beams, for calculating moments for different conditions of the supports. JORGE QUIJANO. Ingenieria (Mexico), March, 1930, p. 123 and 133.—Simple alignment or nomographic charts, of a series of such charts for use in reinforced concrete design, one solving the relation between M and A_s and d for given values of f_s, f_c and N. Left hand scale or line l middle scales A_s and d, and right scale W. All in metric units. The other chart solves the relation $M = CWl^2$. Left hand scale or line l, middle scale M, and right scale W.—C. G. CLAIR AND M. N. CLAIR

Slurry mixing tanks. *Concrete Constr. Eng.* (England), Sept., 1930, V. 25, No. 9, p. 513.—Reinforced concrete has been used exclusively at the Johnson's Works of the British Portland Cement Manufacturers, Ltd., for the construction of slurry mixing tanks. Details of tanks are given. Range in size is from 48 to 66 ft. internal diameter. They are 11 ft. 6 in. deep and the walls are 6 in. from top to bottom. Details of the design and of construction are given.—J. MARIN

Construction of reinforced concrete superstructures. "Practisches Konstruieren von Eisenbetonhochbauten." RUDOLF BAYERL AND ADOLF BRZESKY. 1930, Julius Springer, Vienna, 144 p., 67 illustrations, R. M. 7.00. Reviewed in *Die Bautechnik* (Germany), June 13, 1930, V. 8, No. 26, p. 418.—Design and calculation of superstructures are illustrated. Examples are included for different types of ceilings, columns, slabs, girders and frames. Influence of heat and shrinkage on structure is shown.—A. E. BEITLICH

Reinforced concrete coal bin. *Zement* (Germany), April 17, 1930, V. 19, No. 16, p. 386.—Structure has cross section of 46½ ft. square and capacity of 1200 tons. Total height is 120 ft. Bin rests on four closed frames, which are supported by eight vertical reinforced concrete columns. Foundation consists of continuous slab. Pumping station is located in basement of structure and pumps water to three water tanks on top of bin.—A. E. BEITLICH

Reinforced concrete design simplified. JAMES R. GRIFFITH. *Concrete* Sept., 1930, V. 37, No. 3, p. 35-37.—Chart A, given in Concrete, March, 1928, has been modified to allow higher strength concrete and higher working stresses allowed by the A. C. I. Code. Balanced tensile reinforcing for concrete beams may be had directly from the chart. The factors involved are breadth and

depth of beam, bending moment, steel area, and allowable stress in the concrete.—N. H. ROY

Statics of structures (in three volumes). "Die Statik der Bauwerke (in drei Baenden)." RUDOLF KIRCHHOFF. 1930, Wilhelm Ernst und Sohn, Berlin (Germany), 2nd V., 2nd edition, 368 p., 261 illustrations, R. M. 27.00. Reviewed in *Die Bautechnik* (Germany), June 13, 1930, V. 8, No. 26, p. 415.—Book deals with static calculations of form variations of structures. Construction of bridges (except suspension bridges) and of other kinds of superstructures is discussed. Beams, girders, columns and slabs are analyzed and their calculation illustrated. Ceiling and wall structures conclude book and third and last volume will appear very soon.—A. E. BEITLICH

Reinforced concrete shell roofs. H. SAVAGE. *Concrete Constr. Eng.* (England), Sept., 1930, V. 25, No. 9, p. 490-1.—Theory developed for the design of two kinds of shell roofs: shells curved in one direction and in two directions. Theory covers cases of unsymmetrical loading, any degree of fixation at the boundaries of the shell and any form of the shell itself. Approximate solutions are presented to simplify design. Experiments were made on large scale models to verify degree of accuracy attained in calculations by approximate methods. Main feature in design is reduction of bending moments in the shell. A graphical method of analysis is given for cases where the curve of the shell cannot be expressed mathematically, or shell varies in thickness, or load is complicated. Examples of various types of shell roofs are given. References for further information on shell roofs are cited.—J. MARIN

Reinforced concrete design simplified. JAMES R. GRIFFITH. *Concrete*, Oct., 1930, p. 39-40.—Professor Griffith presents Charts F_1 and F_2 for the determination of stirrup spacing when allowable stirrup stresses of 14,000 and 12,000 lbs. per sq. in. are desired. The formula for spacing conforms to the Joint Committee and A. C. I. Code. Only the excess of shear above 40 lb. per sq. in. is used in the charts. The charts involve breadth of beam, excess unit shear, stirrup spacing, and size of bars.—N. H. ROY

Economic designs of reinforced concrete walls and ceilings using "disk" effect. H. CRAEMER. *Zement* (Germany), July 24, 1930, V. 19, No. 30, p. 703-8.—A theory is derived which explains "disk" effect or mutual influence of neighboring structural parts on account of monolithic structure of concrete. Neutralization of certain stresses takes place. Economic importance is very evident in structures like silos and storage bins. Walls take up part of stresses and eliminate necessity of supporting beams. Diagrams show stresses occurring in such walls. A number of examples of practice indicate that more than 360 cu. yd. of concrete were wasted for construction of ten useless transverse beams in coal bin structure of average size. Other examples show "disk" effect in ceilings where horizontal stresses are taken up.—A. E. BEITLICH

New York subway construction. *Eng. News Record*, Aug. 7, 1930, V. 105, No. 6, p. 200-205.—New York City's third subway system, one of the great construction undertakings of the world is now more than 60 per cent completed. Construction and equipment cost of 55 miles of line will be $650,000,000. Virtually, design of each type of present subway structure is same as employed for corresponding type in older subways. The structure in open cut consists of transverse steel bents every 5 ft. with columns in wall lines and between tracks. Columns stand on concrete footings and concrete jack arches fill between wall columns and roof beams. Subway tunnel structure in rock consists of semicircular concrete arch over each track with row of columns between tracks carrying longitudinal girder against which opposed arches thrust. Soft ground and subaqueous tunnels are lined with cast iron segments with interlining of concrete to give smooth surface. Only exception to this

structure is ¼-mile shield tunnel lined with precast concrete blocks.—D. E. LARSON

Stress transmission in frictional-cohesive materials. R. W. H. HAWKEN. *J. Inst. Eng. Australia* (Australia), July, 1930, V. 2, No. 7, p. 247.—Author propounds and solves a general theorem of stress transmission in frictional—cohesive materials on the verge of movement, and correlates with it results of Rankine, Navier, Bell and Resal. In "general equation," giving the relation between principal stresses, cohesion and friction, it is usually assumed that one principal stress is represented in direction and amount by intensity of applied normal load, given by gravity in earthwork or by the testing machine in compression tests. For cohesive materials, author considers this untrue when movement is just about to take place. The potential tangential resistance to movement, due to cohesion is considered to be a supplementary shear stress introduced as a maximum on one plane in material with infinitesimal cohesion —that is to say non-cohesive material. This one plane will be critical plane in frictional cohesive material. Direction of principal stresses for assumed criteria of incipient movements is deduced by applying principle of component additions and in the ellipse deduced, the general equation is fulfilled. On critical plane, cohesion which is maximum potential resistance to shear, independent of normal pressures, and potential frictional resistance proportionate to normal stress, taken together, equilibrate the shear concomitant with the true principal stresses.—JOHN E. ADAMS

Statics of restrained and continuous beams. FRITZ EMPERGER. *Beton u. Eisen* (Germany), June 20, 1930, V. 29, No. 12, p. 216.—The moment curve can be exactly determined only for simply supported beams. Where restraint exists the moment variation may be studied by considering possible limiting conditions of restraint. Usual assumption of point supports, satisfactory in bridge work does not seem reliable for buildings where the columns act with the beams. Until recently all steel beams were designed for a moment of $\frac{wl^2}{8}$ throughout their entire length regardless of end restraint. The Austrian Reinf. Conc. Committee in 1908 (Heft 5, 1916) conducted some tests on restrained steel beams of 13 ft. spans. At that time restrained concrete beams were designed for a center moment of $\frac{wl^2}{10}$ while $\frac{wl^2}{8}$ was required for steel beams. The tests showed a completely fixed condition for steel beams with ends built in brickwork with portland cement mortar, and in concrete. Only partial fixity was found for brickwork with lime mortar. The Committee then recommended for steel beams so restrained, a resisting moment at center and at supports of $\frac{wl^2}{16}$. Later tests bear out 1908 investigation (c. f. Maier-Leibnitz, *Bautech.* 1929, Heft 20). Building departments of Leipzig and Hamburg have now approved this recommendation. Safety against failure should be governing factor in beam design. The sum of the center and support moments rather than moment at any one point is to be considered. Attainment of elastic limit at any point leads to a readjustment of moment curve, causing higher moments at other portions of beam. In concrete flexibility of design possible in reinforcement and haunching permits original moment distribution between center and supports to exist until failure. Tests deal with this problem. In tests by Austrian Reinf. Conc. Committee (Heft 4, 1913) a fully restrained concrete beam was reinforced for $\frac{wl^2}{24}$ at supports and $\frac{wl^2}{12}$ at center. At failure, the moments had adjusted themselves to fit this steel distribution. It is hoped to continue at some future date tests of duplicates of single span restrained beams already studied, when these beams are parts of rigid frames.—A. A. BRIELMAIER

A new construction principle. (See FIELD CONSTRUCTION—Miscellaneous.)

ROADS AND PAVEMENTS

Concrete roads—joints. *J. Inst. of Municipal County Engineers* (England), Sept. 2, 1930, V. 57, No. 5, p. 22.—The Ministry of Transport and the County Surveyor of Surrey are collaborating for the purpose of investigating the properties of different types of joints in concrete roads, and the most important relating to the experimental section of road are given.—JOHN E. ADAMS

Joints in concrete roads. *Concrete Constr. Eng.* (England), Sept., 1930, V. 25, No. 9, p. 523.—Study of failure of roads recently built in England shows the striking feature that in practically every case the defect is at a joint. A committee of the Ministry of Transport on Experimental Work is investigating the case and in conjunction with highway authorities concerned, intends to open up some of the joints and determine: (1) exact position of the concrete beams under expansion joints and how they behave; (2) what subsidence (if any) has taken place at joints; (3) characteristics of concrete where failures have occurred, and also to collect information as to any special features of drainage, height of embankments and flooding.—J. MARIN

WATER WORKS

Water tower in Stoppenberg (Germany) of 70,630 cu. ft. capacity. A. KONRAD. *Der Bauingenieur* (Germany), March 14, 1930, V. 11, No. 11/12, p. 199-202.—Entire structure is made of reinforced concrete. Tank has cylindrical form, 45.9 ft. inside diameter and 44.3 ft. high. Weight of tank (1430 tons) and live load (3300 tons) are supported by 9 inner columns, 2 ft. 5 in. square, and 12 outer columns, 2 ft. 2 in. by 2 ft. 4 in. All columns are connected by vertical stabilizing beams. Foundation consists of 2217 sq. ft. reinforced concrete slab, 3 ft. 3 in. thick. Underground is expected to sink slowly about 6 ft. on account of undermining by coal mine. Walls and bottom of tank are very heavy reinforced to stand high water pressures. Layers of insulating materials were placed inside of tank but were later removed and replaced by "Betonit" insulation, since small leakage of water occurred. Iron portland cement was used exclusively for entire structure. Its tensile strength was 498 lb. per sq. in.—A. E. BEITLICH

Water tower at Hertford. *Concrete Constr. Eng.* (England), Sept., 1930, V. 25, No. 9, p. 505-10.—The structure is situated in a growing residential district and, for this reason, attention was given to the question of appearance combined with economy. It was decided that appearance of a reinforced concrete tower would give concrete advantage over a steel structure. Details of design are given. Floor of tank is 75 ft. above ground level. Capacity is 200,000 gal. A feature of design was the dispensing of horizontal bracing for appearance by increasing size of supporting columns.—J. MARIN

North Bay's new water supply system. W. B. REDFERN. *Contract Record Eng. Rev.*, April 30, 1930, Vol. 44, No. 18, p. 495.—In connection with rebuilding of water supply system of North Bay, Ontario, a new concrete lined reservoir of 4,500,000 gal. capacity was constructed. Reservoir excavated in hardpan and rock is paved with 1:1½:3 mix reinforced concrete 8 in. thick. Lining of one side is supported on concrete buttresses due to insufficient depth of embankment. Bottom is underdrained, with tile lines and is divided into 45 ft. squares, expansion joints consisting of 12 in. copper strips and elastile.—G. M. WILLIAMS

Enlargement of a water tank in Schwaebisch Gmuend (Germany). *Zement* (Germany), April 17, 1930, V. 19, No. 16, p. 386.—Tank, which is 16 ft. high, 80 ft. long and 50 ft. wide has capacity of 1930 cu. yd. and is made of reinforced concrete. Top of tank is Pilz ceiling, and high early strength cement was used for its construction. Ceiling was calculated for load of 32 in. layer of ground and additional live load for tennis courts, which were placed on its top. Special consideration was given to perfect insulation of walls.—A. E. BEITLICH

ARCHITECTURAL DESIGN

Church of St. Konrad in Freiburg (Germany). C. A. MECKEL. *Zement* (Germany), Aug. 28, 1930, V. 19, No. 35, p. 826-8.—Church is built of reinforced concrete in modern style. It is 65.6 ft. wide, 161.6 ft. long and provides room for 1900 persons. Total interior height is 47.6 ft., that of tower structure is 98.4 ft. Floors consist of concrete slabs, which are specially polished. Roof is vault construction resting on 7 cross beams, with no columns in interior. Use of reinforced concrete throughout makes building fireproof.—A. E. BEITLICH

Modern questions of architectural design. "Die Zeitfragen der Architektur." FRITZ SCHUMACHER. 1929, Eugen Diederichs, Jena (Germany), R. M. 9.50. Reviewed in *Der Bauingenieur* (Germany), Jan. 3, 1930, V. 11, No. 1, p. 17.—Book belongs to most important publications in field of architectural design of modern structures. Different chapters deal with construction of buildings, bridges, towns and marine structures. Special consideration is given to application of colors in construction practice.—A. E. BEITLICH

FIELD CONSTRUCTION

BRIDGES

Fourth Ave. viaduct, Moose Jaw, Sask. *Canadian Engineer*, June 24, 1930, V. 58, No. 25, p. 691-692.—To replace a timber trestle, City of Moose Jaw has built a mushroom flat slab viaduct consisting of 30 ft. roadway and two 5 ft. walks with spans of 30 ft. supported on concrete columns. Reinforcing of flat plate slab consists of ½ in. plain bars with a 6 in. spacing in two way mat and diagonal bands with a 3 in. spacing in bottom of plate. Concrete mixture was 1:2:4 by volume using a clean coarse sand and a crushed gravel. Consistency was such that mixture would flow slowly into place with little puddling or jarring. Tests at 34 days showed a strength of 4000 lb. per sq. in. Warm mixing water and ½ per cent of an admixture was used.—G. M. WILLIAMS

The Montreal South Shore bridge over the St. Lawrence River. *Eng. and Con.*, Sept., 1930, p. 330-336.—Substructure for South Shore bridge required 62 permanent piers with many types of foundations. A caisson 127 ft. 9 in. by 50 ft. 6 in. by 47 ft. was required for one main pier. Main pier on the city side was founded on two pneumatic caissons carried to rock. It is 47 by 96 by 150 and 200 ft. and contains 18,000 cu. yd. of concrete. River piers are of 2000 lb. concrete and are faced with limestone from a few feet below water level to a few feet above highest ice level. South approach required a number of piers. Ninety-two thousand cu. yds. of concrete were used in the substructure.—N. H. ROY

Concrete arch bridge carries pipe line. F. M. PRESTON. *Canadian Engineer*, May 27, 1930, V. 58, No. 21, p. 605-606.—Victoria, B. C., has re-

placed an old Howe Truss timber bridge with a reinforced concrete bridge designed to carry two 32 in. diameter steel water supply lines. Crossing 177 ft. long consists of five 16 ft. approach spans and an arch span of 66 ft. with ribs on 7 ft. centers. Arch is of the three hinged type, ribs being precast on their sides of a 1:1:2 concrete mixture and weighing 6½ tons each. Hinges in abutments and at crown consist of brass bushed steel pins turning in cast steel hinges. Approach trestles and abutments on rock were built first and the arch ribs erected by means of a floating derrick. One unit allowed to accidentally drop was recast with quick hardening cement and put in position four days later.—G. M. WILLIAMS

New construction of the Saxon bridge over river Elster in Leipzig (Germany). WESTPHAL. *Der Bauingenieur* (Germany), May 23, 1930, V. 11, No. 21, p. 359-61.—Bridge consists of 12 continuous reinforced concrete beams which rest on two shore abutments and two river piers. Opening between piers is 65.6 ft. and between piers and abutments 54.1 ft. Roadway is 39.4 ft. wide but can be widened to 52.5 ft. Side walks, 19.7 ft. wide are on each side. Larssen steel sheet piling was driven and excavations were made on each river side. One shore abutment and one pier were erected in one excavation. Pile driving was carried out under great difficulties, since underground was very soft. Two pumps were put into operation. Roadway consists of 8.7 in. thick concrete layer with asphalt top. About 24,700 cu. ft. concrete were used for its construction, and abutments and piers consumed 76,500 cu. ft.—A. E. BEITLICH

Quebec bridge roadway construction. JAQCUES JOBIN. *Canadian Engineer*, Aug. 26, 1930, V. 59, No. 9, p. 261-264.—The Quebec Bridge built by the St. Lawrence Bridge Co. and opened to railway traffic in 1917, carries two railway tracks 32 ft. 6 in. center to center, supported on four through plate girders, attached to girder floor beams. Space of 17 ft. 6 in. between interior plate girders was only portion available for roadway purposes. Steel floor beams and stringers attached to the plate girders carry reinforced concrete slab poured in place, which serves as wearing surface of roadway. To allow for expansion and contraction of supporting steel structure, expansion joints of overlapping plate type were provided to permit of a maximum movement as much as 3½ in.—G. M. WILLIAMS

The reinforced concrete arch bridge near Conflans-Fin-d'Oise. O. S. *Zement* (Germany), Aug. 1930, V. 19, No. 34, p. 804-7.—Bridge over river Oise near its junction with Seine river was constructed between March 1928 and August 1929, and was opened for traffic in December 1929. Arch has span of 414 ft. with a height of 55 ft. Cross-section of both arches is rectangular, 6 ft. 10 in. high in center and 4 ft. 2 in. high at abutments. Roadway is 16 ft. 6 in. wide with two 3 ft. 4 in. sidewalks. Vertical columns are spaced about 20 ft. on centers and have octagonal cross-section with 8 in. diameter. Columns are connected with cantilevered transverse slabs on which roadway is built. Latter consists of continuous concrete slab. Arches are hollow for 184 ft. from center on both sides. Wall thickness varies from 1 ft. 2 in. to 1 ft. 6 in. Description of reinforcements and their arrangement is given. Abutments were built upon concrete pile foundations.—A. E. BEITLICH

Handbook for reinforced concrete III. (See ENGINEERING DESIGN—Bridges.)

BUILDINGS

New buildings of the City of Karlsruhe (Germany). OTTO LINDE. *Zement* (Germany), Aug., 1930, V. 19, No. 33, p. 780-2.—Several new structures, including two school buildings, made of reinforced concrete are described. Special consideration is given to modern economic construction methods.—A. E. BEITLICH

Lightweight floors and concrete units in office building. *Concrete*, Sept., 1930, V. 37, No. 3 p. 21.—New type of floor panel—rivet grip steel deck construction—used in erection of 23-story building, has as supporting members steel bar joists, placed in the usual way on principal girders of structural frame and anchored at ends. At midspan a reinforced concrete bridging beam supplies a higher degree of lateral rigidity than otherwise possible. The ribbed steel pans are of 20-gauge metal and provide a solid, leak-proof decking or form for the 3-in. reinforced concrete slab placed over the deck. Exterior walls throughout the building are backed up with Haydite concrete units, standard, half and special size units, totaling 100,000 were used. Absorption test was made as follows on Haydite units and competing material: Four-inch slab of Indiana limestone, representing exterior facing material was placed flatwise in broad and shallow pan of water. Back-up units were then set in mortar, with the thickness of mortar joints between units. Water depth of 2 in. was maintained throughout. Four months later moisture had penetrated both slabs of limestone and the clay tile to practically full height, stopping at level about even with the uppermost shell. Penetration in Haydite units extended from 1 to 1½ in.—C. BACHMANN

Skeleton structures of reinforced concrete. G. RUETH. *Zement* (Germany), July 31 and August 7, 1930, V. 19, No. 31 and 32, p. 728-33, 755-8.—Use of high early strength cement for construction of lower parts of high skeleton structures is recommended in order to decrease dimensions of supporting columns as far as possible. Description of a number of such buildings illustrates application of this construction method for apartment and office buildings, water towers, industrial buildings, hospitals and warehouses.—A. E. BEITLICH

Rapid methods for reinforced concrete construction. WILHELM PETRY. *Der Bauingenieur* (Germany), Jan. 17, 1930, V. 11, No. 3, p. 35-9.—Modern methods for reinforced concrete construction enable erection of such structures with greater speed than was possible several years ago. Great 6-story warehouse in Kiel (Germany), which rests on deep pile foundation was finished in four months although underground work was done under great difficulties on account of high ground water. Addition to paper plant Scheuffelen in Oberlemmingen (Germany) (cf. *Zement* (Germany), June, 1930, V. 19, No. 24, p. 565-7) is 325 ft. long, 80 ft. wide and 68 ft. high. Its construction was delayed by bad weather conditions but was finished in 3 months. Several more examples are discussed and construction methods described.—A. E. BEITLICH

Modern methods and equipment used on American Can building. M. THOMPSON. *Concrete*, September, 1930, V. 37, No. 3, p. 13.—Mixing plant was designed to speed up the handling of both the raw materials and mixed concrete to place 700 cu. yds. daily on American Can Co. building. From bins sand and gravel were delivered to the three mixers by gravity, through weighing and measuring devices. Quantity of water, including any in aggregate, was about 7 gal. per sack of cement in column concrete and 7½ gal. for floor concrete. Proportions were about 1:2:4 for floor concrete and from 1:1½:3 to 1:1:2 for column concrete. Where 2,000 lb. concrete was required, strengths ranged from 4,284 to 4,810 lb. per sq. in. at 28 days. Batches were delivered to a skip at base of hoisting tower, elevated to hopper, then delivered to first of a series of portable belt conveyors, one being 52 ft. long, three each 40, two 37, and one 34 ft. long. Metal forms were used for columns, column heads, drop panels and floor panels. Drop panel forms for flat-slab construction were made in two parts, each containing half the semi-circular opening made by column head. Drop panel forms were supported from the story below by jack frames of 4-by-4 wooden posts and 4-by-6 jackheads, spaced 4 ft. apart. Floor panel forms were rectangular sheet metal panels.—C. BACHMANN

Foundations for library and convention hall of German Museum in Munich (Germany). E. STECHER. *Die Bautechnik* (Germany), March 18, 1930, V. 8, No. 12, p. 197-9.—Museum is located on island in river Isar. Foundations of structures consist of concrete piles. To reach firm stratum 520 vertical shafts were drilled to a depth from 33 to 66 ft. Special movable steel drills were put into operation. Shafts were conically enlarged at bottom. Concreting was carried out with plastic concrete without interuption until ground water level was reached, then upper part of foundations was finished. Concrete piles are connected with horizontal beams on which superstructures are erected. (cf. Hoffmann. *Zement* (Germany), May, 1930, V. 19, No. 20, p. 470-2.)—A. E. BEITLICH

How to save in concrete form work. A. B. MACMILLAN. *Concrete*, Sept., 1930, V. 37, No. 3, p. 27.—In assembling form work for a typical tower, forms are erected one story at a time and thoroughly braced with diagonal braces of 14 x 6 in. material and 3 x 6 in. bracing placed horizontally. Horizontal diagonal wires are twisted across the tower form work just above and below the horizontal 3 x 6 in. bracing. Form work for a story is supported at the corners by "Ell" blocks. Double waling strips serve at main holding members. Waling strips are extended along full length of tower on outer sides when there is only a small offset between face of column and face of wall.—C. BACHMANN

The future of reinforced concrete without forms. G. HOFFNER. *Le Constructeur Ciment Armé*, June, 1930, No. 129, p. 136.—Article urges use of steel and reinforced concrete type of construction conforming to American practice. Standardization of units will permit extensive use of precast units and will eliminate wasteful timber forms, replacing them by standard metal molds. A reinforced concrete building comprising about 12000 sq. yd. of floor area was erected in accordance with this system by Michelin plant at Clermont-Ferrand, the entire job taking only 6 months for its completion. Foundations were finished by end of June 1929, the skeleton and floors by October 1929. About 1200 sq. yd. of floor, including supports and beams, were placed every 10 days. The tests of the finished structure yielded satisfactory results. Other buildings of this type in France are: the auditorium of hotel at Hermitage, hotel Majestic at Clermont-Ferrand and the Renault garages at Saint-Etienne.—M. A. CORBIN

Reinforced concrete structure of new storage and warehouse of the Engelhardt brewery in Berlin (Germany). FR. HERBST. *Zement* (Germany), Aug. 14 and 21, 1930, V. 19, No. 33-34, p. 776-9, 800-4.—New building is located on Lake Rummelsburg near Stralau and was erected from fall 1929 to spring 1930. It is a reinforced concrete skeleton structure, with 96,880 sq. ft. floor area and is 192.3 ft. long and 126.3 ft. wide. Room of 192.3 by 45.9 ft. in basement is taken up by 8 decarbonation tanks with total capacity of 11,000 cu. yds. Total height of building is 98.4 ft. Of special interest is heavy insulation of walls and floors of basement and first floor to maintain constant low temperature. Difficulties were encountered in placing foundation on account of ground water. Foundation is one continuous reinforced concrete slab, is 3 ft. 3 in. thick under 6 and 4-story part of building and 2 ft. thick under 2-story part. Ground water was lowered by means of 20 wells. Basement floor is only a few inches above normal ground water level. Stairways were made of reinforced concrete. Pilz construction was used for ceiling slabs calculated for heavy live loads. Slabs from 8.66 in. to 18.90 in. were supported by square or octagonal reinforced concrete columns, diameters of which increased from 2 to 3 ft. Two concrete mixers delivered material to two distribution towers, 118 and 190 ft. high. Aggregates were transported with dump cars from boat to mixer and cement was added to aggregates in dump cars. Total construction consumed 814 tons high early strength cement, 1360 tons portland cement, 250,000 cu. ft. gravel and 745 tons reinforcing steel.—A. E. BEITLICH

How to save in concrete form work. A. B. MACMILLAN. *Concrete*, August, 1930, V. 37, No. 2, p. 31-34.—Author describes a case where a comparatively thin panel wall of reinforced concrete occupies entire space between wall columns or pilasters, and between the floor slab and wall girder supporting floor above. A stub wall is concreted at the time wall girder and floor slabs are concreted. A key left in top of stub helps to unite it with fresh concrete placed upon it. At top the panel wall forms are held in alignment by U-shaped yokes. Wedges or blocks are inserted between yokes and face of column or pilaster to adjust form work horizontally. The inner and outer panel wall forms are held in proper relation to each other by spreaders and tie bolts and a pair of waling timbers at the top. At the bottom, just above the stub wall, there is another pair of waling timbers, or rangers, made of either single 3-by-4's or of two 1-by-6's or two 2-by-6's. Line drawings show details of form work for spandrel or upturned wall beam itself and how form work is connected with form work for wall column or pilaster. Details are application to a building of flat-slab type of reinforced concrete construction in which window area is to be as large as possible. Since the window extends up to underside of floor slab, the wall space immediately above, between floor slab and window sill, must serve both as a wall and as a girder. Since the spandrel or upturned beam is to be continuous with the floor slab, the inner panel of form work must be left open and unobstructed where slab occurs. Here the form work is supported on small precast blocks of concrete whose height is equal to the depth of slab, these blocks being left in place.—C. BACHMANN

Concrete airship hangar of bold design at Sevilla, Spain. (See ENGINEERING DESIGN—Buildings.)

DAMS

Aggregate for Boulder Dam. *Rock Products*, April 26, 1930, V. 33, No. 9, p. 54-55.—John Mocine, Gen. Sup. of United States Lime Products Corp., San Francisco, Calif., proposes novel method of quarrying large dolomitic limestone deposit for producing the 10,000 tons per day of aggregate that will be needed for Boulder Dam. Method consists in driving tunnel 280 ft. back of and parallel to quarry face. Twenty parallel tunnels are to be driven from the main tunnel to within 40 ft. of the face where each terminates in cross tunnels to be filled with powder. When this is shot a slab 40 ft. thick and height of bank will be brought down. Loading and stemming for next shot can go on without waiting for face to be cleared.—EDMUND SHAW

Transportation methods for raw materials for construction of Grimsel dam (Switzerland). W. FRANKE. *Der Bauingenieur* (Germany), March 14, 1930, V. 11, No. 11-12, p. 192-8.—Site of dam is located about 6000 ft. above sea level and transportation of structural materials was extremely difficult. Cement was delivered by rail to aerial tramway 10.5 mi. long which brought materials to construction site. Dam consists of two sections which are separated by natural rock of Mount Nollen. First section will be 377.3 ft. high and 590.5 ft. wide at its base; 445,000 cu. yd. concrete are necessary for its construction. Second part of dam will consume more than 74,000 cu. yd. concrete. Detailed description is given of aerial tramway and concrete distribution arrangements. Two cable cranes which handle 5600 to 6300 cu. ft. concrete per hr. are used and up to 4,000 cu. yd. concrete were placed in one day. Interesting details of construction of three power plants, connected with dam, are given.—A. E. BEITLICH

Power development on the Magog River at Sherebrooke, Que. VERNON R. DAVIES. *Canadian Engineer*, April 29, 1930, V. 59, No. 17.—Sherbrooke Land and Water Power Co. at Sherbrooke, Quebec, has completed a hydro-power development on the Magog River consisting of a concrete dam,

concrete lined head race canal and power house. Installation consists of 2-900 K. V. A., 2400 volt generators driven by 1100 h. p. water wheels with open flume and propeller type runners. Dam foundation consists of rock from which weathered material was removed and a cut-off trench excavated for the entire length of bulkhead and sluiceway sections. Bulkhead portion is a gravily section having maximum height of about 30 ft. To increase stability dowels, 1½ in. rods 10 ft. long, were grouted 5 ft. into the foundation rock on 2 ft. centers near the upstream face. Tests made to determine effectiveness of these dowels indicated they were of doubtful value. Head race canal 15 ft. wide and 15 ft. deep is lined with reinforced concrete walls 2 ft. thick above the sides of the rock excavation.—G. M. WILLIAMS

Power station Kriebstein near Waldheim (Germany) on river Zschopau. KIRSTEN. *Die Bautechnik* (Germany), March 14, April 4 and 11, 1930, V. 8, No. 11, 15 and 16, p. 149-53, 233-7, 247-50.—Big concrete dam was erected to produce power and to protect low lands against high water. Detailed descriptions of four different projects are given. Site of plant is very favorable in narrow valley of river Zschopau. Bedrock consists mostly of granite with a 9 to 21 ft. top layer of soft yellow loam and sand, which was partly removed. On left hand river bank cement was forced into rock voids to make ground impermeable to water. Quarry, located about half a mile upstream, furnished aggregates of high quality which were crushed in special plant. Dam is of overflow type, 787.4 ft. long and 13.1 ft. wide at its crest, radius of curvature is 73.8 ft. Middle part of dam is built as 85.3 ft. wide weir, top of which is 13 ft. below normal water level of reservoir. Overflow is divided into 6 sections, 22.3 ft. wide, which are separated by six 8.2 ft. wide pillars. Height of dam is 86.3 ft. and it is 66.9 ft. wide at base. Joints were made at distances from 65 to 82 ft., sealed by means of sheet copper embedded in bitumen and asphalt. Great number of thermocouples recorded heat developed in interior of dam. Overflowing water is collected in basin 9.8 ft. deep and 105 ft. long where its force is broken. Floor of basin consists of 6 ft. thick concrete slab with 1 ft. top layer of reinforced concrete. Reinforced concrete bridge designed for load of 40.8 lb. per sq. ft. is built over basin to gates at base of dam. Its span is 114.8 ft. Dam is provided with 3 openings at its base, each 8.5 ft. in diameter and being capable to take in 3355 cu. ft. of water per sec. Gates are operated from top of dam. Three 118 ft. long high pressure pipes lead water to 3 turbines. Diameter of two of those pipes is 7.9 ft., third pipe for small turbine is 5.9 ft. Power station is reinforced concrete skeleton structure with 3 turbines. Structural materials were stored on left hand side of river. Cement, trass and sand were transported by cableway to central mixing plant and silos. Four towers distributed concrete. 1020 cu. yd. was placed daily. Two concrete mixtures, consisting of 440 lb. portland cement and 165 lbs. trass and 396.8 lbs. portland cement and 143.3 lb. trass for 35 cu. ft. concrete were used. Water impermeability of concrete was very much improved by addition of trass. Aggregates consisted of 15 parts sand (0 to ⅛ in.), 15 parts sand (0 to ¼ in.), 41 parts gravel (¼ to 1¼ in.) and 29 parts gravel (1¼ to 2½ in.) Laboratory at site of construction tested strength and water permeability of all mixtures.—A. E. BEITLICH

MISCELLANEOUS

Repairs of Bildwasen tunnel (Germany). K. SCHAECHTERLE. *Die Bautechnik* (Germany), April 25, 1930, V. 8, No. 18, p. 271-3.—Railroad tunnel of 1880 ft. length was badly damaged by water and engine smoke. Rock layer on top of tunnel was partly removed and replaced with concrete filling. New drainage system was built.—A. E. BEITLICH

Guniting sea-water structures. *Concrete Constr. Eng.* (England), Sept., 1930, V. 25, No. 9, p. 521.—Article refers to various wharf constructions to

point out that experience shows importance of ensuring that top surface of the slab be made water tight. Special methods are given with preference to method of applying grout by cement-gun to super structure and under side of the deck. This largely reduces the rusting of the steel reinforcement. Examples given to illustrate the success of the method.—J. MARIN

Construction of coal bin in Duisburg Ruhrort (Germany) with 11,000 tons capacity. HEINRICH BUTZER. *Der Bauingenieur* (Germany), March 14, 1930, V. 11, No. 11-12, p. 190-2.—Coal silo structure consists of 32 cells; it is 367.5 ft. long, 45.9 ft. wide and 55.8 ft. high, with capacity approximately 11,000 tons. Cells are provided with conical bottom, 22 (for coarse coal) show an angle of 50 degrees and 10 (for fine coal) are built with angle of 65 degrees. Unfavorable underground conditions made foundation on reinforced concrete piles necessary. Entire structure is divided into 3 parts by 2 expansion joints.—A. E. BEITLICH

Successful transit mix concrete. R. M. BELL. *Rock Products*, June 7, 1930, V. 33, No. 12, p. 109.—Brief description of operation of Swigert, Hart and Yett, Portland, Ore., where portable charging plant was introduced to shorten the haul on a 60,000 yd. job. Not many details are given.—EDMUND SHAW

Winter construction. A. SUTTER. *Der Bauingenieur* (Germany), March 7, 1930, V. 11, No. 10, p. 160-3.—Best way to make construction work possible during severe cold weather periods is to protect whole structure against cold outside air. Then the temperature can be kept within normal range by heating with hot air. Raw materials must be preheated. Addition of anti-freezing agents to concrete is not advisable, since this mostly causes considerable loss in strength. From economic view point winter construction must be highly recommended. Costs for heating and protecting amount to only a small fraction of wages, and work is provided for laborers during cold weather seasons.—A. E. BEITLICH

Notes on concrete and reinforced concrete made on trip through United States of America to Eastern Asia. E. PROBST. *Der Bauingenieur* (Germany), March 14, 1930, V. 11, No. 11-12, p. 180-6.—Author gives his impressions gathered on trip through U. S. A., Japan and China. He discusses modern American methods for concrete road and dam construction, use of lightweight concrete and application of concrete for railroad construction jobs. Economic conditions for cement and concrete in Japan and China are characterized and their new standard specifications and methods are criticised.—A. E. BEITLICH

Construction of a waste water sewer pipe system under river Rhine near Koeln (Germany). OTTO WERKEN. *Die Bautechnik* (Germany), March 7, April 18 and May 2, 1930, V. 8, No. 10, 17 and 19, p. 137-9, 261-4, 285-8.—Increasing population of city of Koeln made construction of new sewage disposal plant necessary. New structure is located on right side of river Rhine. Sewage from old plant on left side had to be led underneath river to new plant. Two sewer pipes, 6.1 ft. and 3.1 ft. in diameter, capable of carrying 425 to 450 gal. of water per hr., were built in one single concrete body. Pipes having total length of 1119 ft. were laid in excavation in river. Connections were made under water by means of diving bells. Detailed description of interesting placing method and several illustrations are given.—A. E. BEITLICH

Tall concrete chimney construction. *Canadian Engineer*, June 17, 1930, V. 58, No. 24, p. 683-684.—A concrete chimney 422 ft. 6 in. high and 8 ft. in diameter has been erected by the Horne Copper Corporation, Noranda, Quebec. Base on solid rock consists of a concrete ring 7 ft. 6 in. deep, 35 ft.

outside diameter and 23 ft. inside diameter, reinforced top and bottom with rings of 1 in. bars and ¾ in. radial bars. Concrete shaft was designed to resist combined loading of its dead weight and a wind pressure of 25 lb. sq. ft. of projected area. Connection of shaft to base is made by means of 206 1 in. steel dowels and shell is reinforced by both vertical and horizontal steel. To withstand acid action of gases stack is lined with a 4 in. acid resistant, vitreous brick laid up in special acid proof mortar, built in 45 ft. sections supported on ledges which are protected by a lead flashing where exposed. In addition inside surface as well as the outer 100 ft. of the concrete surface of the shaft is covered with an acid resistant bitumastic paint. Concrete mix for base was 1:2:4 cement, sand and gravel and for shaft a 1:2:3, with average slump of 6 inches. Adjustable all steel forms supported by an interior scaffold were used.—G. M. WILLIAMS

American foundation methods. H. GRIESEL. *Der Bauingenieur* (Germany), Feb. 7, 1930, V. 11, No. 6, p. 91-6.—First part of article describes foundations with wooden piles, concrete piles, reinforced concrete piles, Raymond piles and combinations of wood and concrete piles. Advantages of Raymond piles are especially characterized. Pile driving and necessary equipment are illustrated, and examples of practice are shown. Second part deals with caisson methods. Caissons can be placed either by excavating or by means of compressed air. Foundation job during construction of Delaware bridge between Philadelphia and Camden is described with dimensions and detailed graphs. Construction of Holland tunnel under Hudson river is example of foundation with compressed air method. Several foundations of skyscraper buildings are illustrated.—A. E. BEITLICH

Winter concreting methods applied on contract of moderate size. ROBT. C. JOHNSON. *Concrete*, Oct., 1930, V. 37, No. 4, p. 13-16.—Concrete plant on 4,000 cu. yd. job of wall-bearing design was limited to concrete mixer. Responsibility for quality depended upon competent men and mechanical controls were eliminated. Aggregates were measured by wheelbarrow, and 8 to 10 test samples were taken daily. Proportions were 1:2:4. One man was detailed through winter months to take three test cylinders from each sample of concrete, to be broken at customary periods, and to keep temperature records. Specifications contained two clauses: temperature of 60 to 80° for concrete being poured, and that freshly placed concrete be kept at minimum of 70° for at least five days after concreting. Following equipment was used for protection: Vertical steam boiler with 100 lb. pressure capacity; 150 lin. ft. steam hose, about 100 salamanders, canvas, 10,000 sq. ft.; Sisalkraft, 20,000 sq. ft. Total cost of material used directly for winter work and winter work labor costs amounted to about $1.04 per cu. yd. of concrete placed on the entire job.—C. BACHMANN

Remarkable foundation jobs during construction of railroad Jungfernheide-Gartenfeld in Berlin (Germany). MAX JUSSEL. *Die Bautechnik* (Germany), January 24 and February 7, 1930, V. 8, No. 4 and 6, p. 45-8, 74-7.—Railroad crosses suburban tracks on bridge of 196.8 ft. span. Abutments show very interesting construction. Unfavorable underground conditions made very deep foundations necessary. Chemical analysis of ground water showed presence of aggressive and corroding substances. Abutments were founded on caissons, made of high early strength reinforced concrete, 1:1.5:3 mix. Concrete of normal cement in 1:2:6 mix was used for construction of base of abutments. All parts exposed to ground water were protected by wall of acidproof bricks, cemented with high quality cement mortar (1:2). Three inner walls divide each caisson into 6 cells. These walls were provided with openings. Excavated material was brought out by two elevators. Con-

crete from mixer of 13½ cu. ft. capacity was distributed by tower and dump cars. Plastic concrete was used for caisson construction. Hardened concrete was very dense. Placing of caissons took 17 days at rate of approximately 6 ft. per 24 hours.—A. E. BEITLICH

Reinforcing structures with gunite. J. F. SALMON. *Canadian Engineer*, Sept. 2, 1930, V. 59, No. 10, p. 281-283.—The Canadian National Railway has made use of gunite to protect and prolong the life of structures which would otherwise have required replacement at high cost. Disintegration of Mount Royal tunnel at Montreal resulted in high maintenance cost as well as danger to traffic due to falling rocks. Using no reinforcement a ¾-in. coating of gunite was applied to interior at a cost of $30,000, since which time all trouble has been avoided with no cost for maintenance. Brick piers in the Humber River bridge at Weston, Ont., were disintegrating and it was decided to replace them at an estimated cost of $500,000, after an earlier attempt to retard disintegration by guniting directly into the brick surface, which was not successful. The old gunite coating and all loose material was removed, joints raked out and surface sand blasted. Metal fasteners were grouted into the joints and reinforcement consisting of rods, angle irons and a 2 in. x 2 in. No. 8 wire mesh were attached with a space of 1½ in. between reinforcement and face of pier, after which gunite was applied. Cost of Weston job was $60,000. Repair of Cap Ronge viaduct, Quebec, at a cost of $70,000 saved rebuilding at a cost of $2,000,000. Concrete piers of Blende River viaduct were repaired with gunite for $65,000, thereby postponing a replacement charge of $1,000,000. All these repairs were made without interference with traffic.—G. M. WILLIAMS

Construction of the German waterway commission (Reichswasserstrassen Verwaltung) in 1929. GAEHRS. *Die Bautechnik* (Germany), January 10, 24, February 7, 21, 1930, V. 8, No. 2, 4, 6 and 8, p. 21-5, 48-52, 78-82, 114-8.—Comprehensive article describes new construction, enlargements and repairs of ship channels, locks, power stations and harbors in Germany including following concrete and reinforced concrete structures: (1) lock Anderten near Hannover, (2) highway bridge near Peine with 190.3 ft. span, (3) abutments of 278.9 ft. railroad bridge Peine-Braunschweig, crossing Mittelland channel at angle of approximately 41 degrees, (4) three-hinged reinforced concrete arch bridge near Meerdorf with 157.5 ft. span, (5) sewer systems near Aue and Allen consisting of high pressure concrete pipes with 2 openings of 40.4 sq. ft. and 3 openings 12.79 ft. square, (6) new locks in river Weser, main lock being 738.2 ft. long and 41.0 ft. wide, and (7) 7 locks in the river Neckar. Concrete used for all these structures was made from low lime portland cement, since ground water had corroding action.—A. E. BEITLICH

Use of under-water cast concrete in Sweden. F. TRIER. *Die Bautechnik* (Germany), February 21 and March 7, 1930, V. 8, No. 8 and 10, p. 109-12, 142-4.—Methods of under-water casting of concrete are described. Process can be carried out (1) with pipes, (2) with caissons, (3) by pouring and (4) by pressing cement mixtures. Best mixtures of concrete for pipes, movable in vertical direction, range between 1:2.5:3 and 1:4:5 (cement, sand, gravel). Caisson method requires mixtures from 1:2:4 to 1:3:4. Bridge over Skellefte river was built by pipe method. Concrete was poured in layers 1 ft. thick and 3 ft. wide, special care being taken to prevent concrete from sinking in pipe below water level. Concreting was continued through 3 days and 3 nights. Caisson method was used for construction of foundation of one pier of Klara bridge in Stockholm. Methods (3) and (4) can be used only when water is not very deep. Laboratory tests were made to study effect of working, consistency and proportioning of mixture and composition of aggregates. Results showed that concrete cast under water is influenced much more by above factors than ordinary concrete. Proper consistency must be maintained. Cement content

must be higher than for ordinary concrete to obtain same strength. Percentage of fine material should be slightly greater than indicated by Fuller curve. Formation of mud must be prevented by continuous pouring. Numerous construction jobs are described, illustrating applications of above methods. More detailed description is given of construction of coffer dam in Beckholmen (Sweden), and quay near Wallvik (Sweden). (cf. W. Nakonz. *Die Bautechnik* (Germany), Jan., 1930, V. 8, No. 3, p. 35-6.)—A. E. BEITLICH

Waterproofing of concrete structures. H. R. LORDLLY. *Contract Record Eng. Rev.*, April 16, 23 and 30, 1930, V. 44, No. 16-17-18.—Methods of waterproofing concrete structures has not kept pace with increased use of concrete. Experience has shown that the old idea of "a little more cement in mortar or a richer finish" does not give satisfactory results. In a review of waterproofing, four classes of structures are involved: (1) heavy structures exposed to high heads of water, such as dams; (2) lighter structures such as reservoir walls which may be waterproofed by using membrane near water side of wall or by use of admixture; (3) unit pieces of artificial stone or concrete waterproofed during manufacture with an admixture and (4) foundation walls in contact with wet soil which can be protected by tarring or asphaltic paint. Requirements for a perfect membrane waterproofing include flexibility, elasticity, toughness and tensile strength of fibre and ability to absorb and retain material used to saturate membrane fibres. Pointers on waterproofing basement floors, basement or cellar walls, concrete roof, waterproofing by admixture, surface waterproofing and surface waterproofing with impregnating solutions are included. Deductions from experience in placing sub-aqueous concrete through spout or tremie are summarized.—G. M. WILLIAMS

A new construction principle. GEORG EHLERS. *Der Bauingenieur* (Germany), Feb. 21, 1930, V. 11, No. 8, p. 125-32.—Construction of coal bin with capacity of 140,000 cu. ft. shows application of new principle in reinforced concrete construction practice. Structure is 197 ft. long and 32.8 ft. wide and consists of 8 single cells, each 31.2 ft. high. Total height of structure is 75.9 ft. It is supported by 2 single frames at the ends and 3 pairs of double frames under bins. Dimensions of columns of double frames are 2 ft. 9 inches by 4 ft. 3 inches, those of single frames are 2 ft. 6 inches by 4 ft. 3 inches. Distance between columns of double frames is 8 ft. End and double frames are placed 42.6 resp. 43.9 ft. apart. Main feature of structure is complete lack of stabilizing beams and girders. Walls 8 in. thick and bottom 10 in. thick are unsupported over about 42 ft. and only their unique connection and joint compensation of certain stresses made construction possible. Mathematical calculations on which construction was based are fully described. (cf. H. Craemer, *Zement* (Germany), July 24, 1930, V. 19, No. 30, p. 703-8.)—A. E. BEITLICH

Winter jobs in concrete and reinforced concrete construction. WILHELM PETRY. *Der Bauingenieur* (Germany), March 14, 1930, V. 11, No. 11/12, p. 175-9.—Author describes a number of winter jobs: construction of monolithic reinforced concrete stack, 262.5 ft. high, for ammonia plant in Merseburg (Germany), foundations for asphalt plant, reinforced concrete building for filtration plant, upper stories of a big warehouse in Leipzig (Germany), two new plant superstructures and enlargement of big hospital in Muenster in Westfalen (Germany). Experience, with those structures lead author to following suggestions: High alumina cement is used with advantage due to high heat of reaction which is generated during setting process. Materials must be preheated and least amount of water should be used for mixing concrete. Reinforcements and formwork must be cleaned from ice and snow. Working and placing of concrete should be made in rooms, which are protected

against frost. After placing, concrete must be covered with canvas, straw or other similar materials, especially over night, or can be directly heated by means of coke burners.—A. E. BEITLICH

Damming, blowing and sealing in crib house construction. CHAS. C. MOODY. *Concrete*, Aug., 1930, V. 37, No. 2, p. 13-16.—In building the crib house, or tunnel terminus, for the water intake on a large power house construction job in Illinois, novel method of driving 14 in. interlocking sheet piling was involved. In order that the sheet might go down straight into the ground the first pile was driven but 10 ft. Another was started and driven 8 ft., another 6 ft., and another 4 ft., and the last 2 ft. Then the hammer was started again on the first, and each one driven 2 ft. more. The steel sheeting was but 12 in. from the building at top and in its driving the piling had a tendency to go toward the building, leaving 9 in. in which to work at bottom. Depth of excavation was about 33 ft. below top of sheeting. With specially devised pipes and air hose, only a very short time was required to remove all sand and stones to the depth required. The slot, between steel sheet piling and old foundation was sealed by concrete placed through an 8 in., 16 gauge galvanized sheet tube 25 ft. long with lower end sealed. When the pipe was full, it was slowly raised to release wood seal at bottom and operation continued until concrete in slot formed a layer 4 ft. thick. When excavation in cofferdam had proceeded to approximately same elevation as seal on opposite side of sheeting, water was let out of slot by burning a hole in steel sheet just above the concrete level.—C. BACHMANN

ROADS AND PAVEMENTS

Modern European developments in road construction methods. E. NEUMANN. *Die Bautechnik* (Germany), Feb. 14, 1930, V. 8, No. 7, p. 90-4.—Development of modern road construction methods in Europe, especially in France and Italy, is described. Special consideration is given to concrete roads. —A. E. BEITLICH

Old Pavements embedded in widened highways. *Concrete*, Sept., 1930, V. 37, No. 3, p. 17.—Design worked out salvaged old 18 ft. pavement laid 8 years ago on National Old Trails road out of Indianapolis and consisted of two thickened edge slabs 10 ft. wide and the resurfaced center portion. Resurface has minimum thickness of 5 in. over old pavement and additional foot on each side is 9 in. thick. Reinforcement placed over center portion only, consisted of an assembled bar mat of ½ in. square deformed bars. Transverse bars were 20 ft. 10 in. long with ends bent around 180 deg. for anchorage. Two construction joints were provided where the side slabs join the center portion, and a longitudinal dummy joint 1½ in. deep and ¾ in. wide down center of middle section.—C. BACHMANN

Concrete road construction in Germany. "Betonstrassenbau in Deutschland." RIEPERT. 1929, 311 pp. Zementverlag, Charlottenburg (Germany), R. M. 4.80. Reviewed in *Zeitschrift des oesterreischischen Ingenieur und Architekten Vereins* (Austria), April, 1930, V. 82, No. 15-16, p. 136.—Technical development in concrete road construction during the recent years is described. Standard specifications for road construction and construction materials are discussed.—A. E. BEITLICH

Cement and bitumen for concrete road construction. WALTER OBST. *Teer und Bitumen* (Germany), July, 1930, V. 28, No. 19, p. 315-6.—Concrete which is made with an addition of tar or asphalt emulsions to mixing water is

excellent road material. These additions do not lower cementing properties or strength of cement. Blast furnace slag cement is especially suited for this purpose. Discussion is given of several American, French and Swiss patents and construction methods are described.—A. E. BEITLICH

Concrete roads in the Elbe river region near Hamburg (Germany). ADOLF WIESE. *Die Bautechnik* (Germany), Feb. 1930, V. 8, No. 7 and 14, p. 106-8, 221-3.—A number of new concrete roads are described. Article includes details of interesting construction methods.—A. E. BEITLICH

Concrete and asphalt road surfacing. R. E. CLARKE. *Cont. J.* (England), June 4, 1930, V. 102, No. 2660, p. 1819.—Variation in length of road slabs is caused by contraction during hardening amounting to $\frac{1}{3}$ in. in 50 ft., expansion and contraction due to temperature change, causing $\frac{1}{4}$ in. in 50 ft. for 80° F. variation, and a much smaller change in length due to alternative wetting and drying. Tensile stresses which depend on length of slab, and friction between sub-base and concrete, cause cracks which may be localized by expansion joints. Such joints are weak points due to (1) weakening of bearing value of sub-base from penetration of water, (2) relative vertical displacement of concrete, (3) impact shock at uneven joints, (4) concentrated load at end of slab. These joints may be strengthened by raising bottom reinforcement to near surface, or by building independent supporting slab under ends of main slab. Longitudinal expansion joints may be used as "white lines" and studs inserted at important junctions; and transverse joints made to break joint at 50 ft. intervals. Expansion joints left proud and burnt down with hot iron tend to become damaged by traffic. Low joints grouted with Mexphalt are recommended, joint being dried with blow torch to save time, if necessary. Joint composed of cork and bitumen is now obtainable and is claimed to have power of expansion and contraction without protrusion. Goldbeck's experiments show that coefficient of friction between slab and average sub-base may reasonably be taken as 2. From this and assumed allowable tensile stress on concrete of 50 lb. per sq. in., 8-inch slab should have joints every 48 ft. Rough surface concrete has been successfully obtained by using 2 in. granite as coarse aggregate for top course. Well tamped concrete was brushed with thick brush without disturbing aggregate until laitance was removed to depth of $\frac{1}{4}$ in. It is important to see that aggregate is properly exposed or surface becomes smooth under traffic. Elsewhere matrix has been laid for top course and coarse aggregate afterwards laid on top. Heavy tamping is required and the surface is not so level. Finished surfaces were covered with waterproof canvas on frames to protect from sun rays and winds, and when safe, sprayed with water and covered with 2 in. of continually wetted sand, for four days for "ferrocrete" and 14 days for portland cement. Before traffic was allowed over, the surface was swept and washed and treated with a 25 per cent solution of silicate of soda in three applications. It is thought that hydrate of lime liberated during setting is converted into silicate of lime which is a hardener. Average output with gang of 24 men (including a man checking level of channels) was 280 sq. yd. using a Millar mixer 14 L, which gave 30 per cent over its rated capacity of 14 cu. ft. unmixed. Importance of using first class materials and watching water-cement ratio is stressed. No advantage beyond bringing to the surface a laitance of drowned cement is obtained by tamping a too wet concrete. Care should also be taken to see that sub-base is sufficiently saturated with water before depositing slab, or moisture from concrete will be absorbed and cracks formed. It is also found that cement and fine aggregate are drawn away from surface.—JOHN E. ADAMS.

Roads and road making. *Irish Builder Eng.*, (Ireland) Aug. 30, 1930, V. 72, No. 18, p. 774.—Experiments in connection with design and construction of con-

crete roads and foundations. 3 miles long, 30 ft. wide, formed on a ballast bank varying in depth from 2 to 20 ft. An 8 in. reinforced concrete slab was laid on a 4 in. consolidated bed of clinkers and the surfacing was 2 in. stone filled asphalt mat. The bays of concrete were 14 ft. 6 in. long and full width of road. At every fourth transverse joint, bituminous sheeting was inserted for expansion, and a 12 in. by 8 in. concrete beam was formed under the joint. The mix was 1:2:4 and the reinforcement 4.7 lb. per sq. yd. The road carries 10,000 tons daily and has been used for two years. No defects were observed during the first year but cracks developed later at 14 ft. 6 in. intervals or multiples, obviously where joints in the foundation occurred. The position of the cracks in the asphalt are such as to show that heavy vehicles depress the edge of slab below level of those they are approaching. It is found too, that the slabs twist upwards and downwards as the temperature varies, and that contact with subsoil may be lost at edges during some periods. Interlocking joints would appear to remedy these defects and the subject is being investigated by Ministry of Transport.—JOHN E. ADAMS

Keeping ahead of the times in paving practice. *Concrete*, August, 1930, V. 37, No. 2, p. 22-24.—Continual effort on the part of engineering department and contractors to take advantage of all betterments and to pioneer in methods is evident in quality of concrete pavement placed in Bethlehem, Pa. Crushed and washed limestone screenings or chips are used as fine aggregate. This material was adopted because of its considerably lower price and because it compared favorably with Ottawa sand. Its use has resulted in increased compressive strengths in test cylinders and pavements. Absorption tests made from time to time are closely supervised and conducted under laboratory conditions. Slab now laid is uniform 7 in. thick and feature of design is use of thickened edges along car track areas, manholes, etc. Thickened edge is not used along curb and gutters or longitudinal joints. Pavements are divided longitudinally for traffic guidance and to facilitate laying. Longitudinal joints are made with deformed plate. Dowels are spaced at 3 ft. intervals. No dowels are used in transverse joints. A deformed metal plate carries a premolded filler. Plate is pointed with hot asphalt and filler pressed on with road roller.—C. BACHMANN

Quebec bridge roadway construction. See FIELD CONSTRUCTION—Bridges.

WATER WORKS

New McTavish pumping station, Montreal, Que. C. J. DESBAILLETS. *Contract Record Eng. Rev.*, April 2, 1930, V. 44, No. 14, p. 385.—McTavish Pumping Station, rebuilt and enlarged by Montreal Water Board, together with reservoir serving high level portions of the city is of Scotch baronial style of architecture to conform with nearby buildings of McGill University. Exterior is of random ashlar limestone and reinforced concrete frame with footings in solid rock. Floor slabs are 4 in. to 6 in. thick except around conduits where 8 in. of concrete is used as filler with 1½ in. of cement mortar finish. Reservoir is excavated in solid rock but to reduce seepage, bottom is paved and side walls waterproofed. Pavement consists of 6 in. concrete slab, reinforced with "Steel crete," divided into panels 20 ft. x 30 ft. with ⅞ in. Minwax expansion joints. Pavement was carried five feet up side walls with remainder of walls coated with gunite. Pavement 20 ft. wide has been placed outside retaining walls at top to intercept surface water from higher ground.—G. M. WILLIAMS

Enlargement of water tank in Schwaebisch Gmuend (Germany). (See ENGINEERING DESIGN—Water Works.)

North Bay's new water supply system. (See ENGINEERING DESIGN—Water Works.)

Reinforced steelwork tower, Harpenden. *J. Institution Municipal County Eng.* (England), Sept. 2, 1930, V. 47, No. 5, p. 262.—Steelwork in a 350,000 gallon capacity water tower, 85 ft. high forms a rigid, pre-erected steel structure designed to carry the dead weight of the temporary centering and wet concrete. No scaffolding is required, centering being suspended from the steelwork. In this case, when steel is initially stressed by the dead load, and before the concrete sets round it, a higher working stress is permissible for watertightness. To avoid irregular cracks, the planes of stoppage in concreting were predetermined, and joints grooved in the water face and pointed with an elastic compound. No waterproofing compounds were added and tests showed efficient watertightness. The tank is carried on three circles of columns, containing 12, 12 and 6 columns respectively, all suitably braced radially and circumferentially.—JOHN E. ADAMS

SHOP MANUFACTURE

How products manufacturers may increase business volume. AUSTIN CRABBS. *Concrete*, August, 1930, V. 37, No. 2, p. 17-19.—From the writer's own business experience it is his belief that a products manufacturer may logically and profitably become a dealer within following limitations: (a) He may be a jobber (or a manufacturers' agent) for various concrete specialties not made at his plant. (b) He may be the manufacturers' agent for incombustible building specialties other than concrete products. (c) He may deal in so-called permanent building material specialties in common use but which may not be sold by other local dealers to any great extent. Products manufacturer is supposed to be equipped to make and sell materials to be bought and used by contractors in construction. If he undertakes to enter contracting business as sideline he will be competing against very contractors to whom he hopes to sell some of materials he manufactures.—C. BACHMANN

New dry paint for the concrete brick industry. BELANI. *Zement* (Germany), July, 1930, V. 19, No. 29, p. 690.—New Paint is prepared from iron ore of high purity from Kaernten (Austria) which contains up to 94 per cent Fe_2O_3 and Fe_3O_4. It is ground to fineness of 2 per cent residue on sieve with 6400 meshes per $cm.^2$ Paint is absolutely weather- and fade-proof. SO_2 and H_2S have no effect and it stands temperatures up to 160° C. without darkening.—A. E. BEITLICH